SULPHUR

The Magazine of World Sulphur Industry

No. 23 *DECEMBER*, 1958

ISSUED BY

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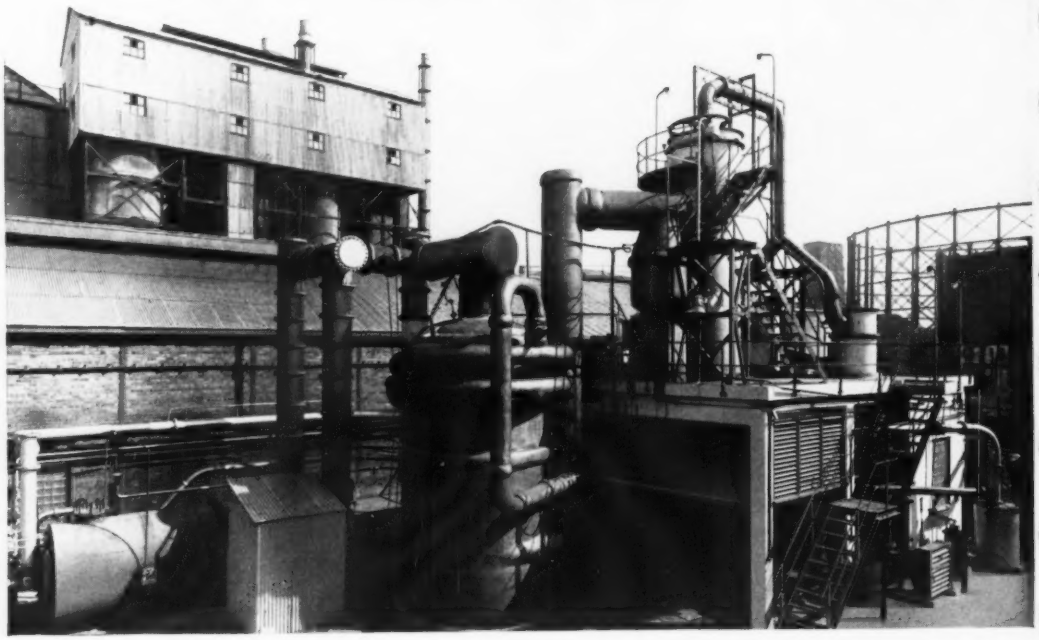
WET CONTACT PLANTS

for sulphuric acid production from hydrogen sulphide



Wet contact plants are an efficient and economical means of producing sulphuric acid from H_2S gas, which may be derived from ammonium sulphate saturators or from liquid purification of coal gas.

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PRODUCTION PROGRAMME

end 1957	70,000 *tons*	
end 1958	350,000 *tons*	
end 1959	700,000 *tons*	
end 1960	1,000,000 *tons*	
end 1961	1,300,000 *tons*	

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We are indebted to Farbenfabriken Bayer A.G., Badische Anilin & Soda Fabrik, Sachtleben A.G. for information and illustrations placed at our disposal on West Germany. Also to the Pan American Sulphur Company, Laporte Industries Limited and San Telmo Iberica Minera S.A. Photographs on pages 21 and 22 were kindly made available by the Albertan Government, and on page 39 by the British Petroleum Company.

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Local index	All firms contained in the alphabetical index have been listed according to town and district, an invaluable aid to both foreign and domestic buyer.
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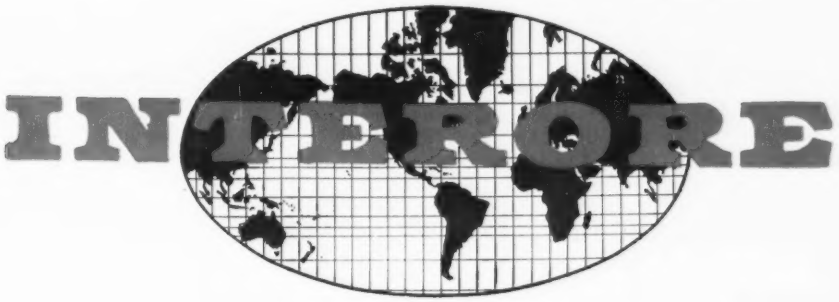

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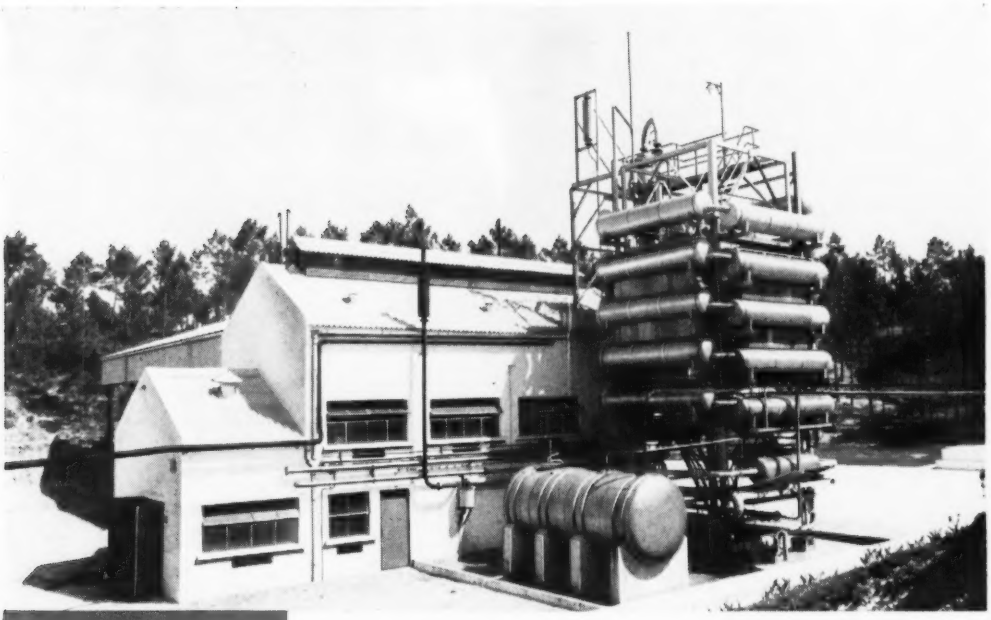

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Review

World sulphur prices resumed their decline during the past three months. Posted brimstone quotations, based on U.S. price for bright Frasch sulphur of $25 per ton f.o.b./f.a.s. remained unchanged, but the practice of quoting "delivered" prices incorporating disguised discounts has become more widespread. Highlighting the mounting competition is the decision by European pyrites producers to reduce price with effect from 1st January 1959 by 10 shillings to 57s. 6d.-67s. 6d. per metric ton f.o.b. Despite the anticipated drop in residues values this reduction may be adequate to arrest the past trend of pyrites use being abandoned in favour of brimstone. The combined effect of low freight rates and low sulphur cost continues to benefit consumers.

World supplies of sulphur in recent months approached balance with apparent demand as the result of efforts by several sectors of the industry cutting back production; this, however, raised the proportion of unemployed production capacity. New dome capacity in the U.S.A. and world wide expansion of recovery facilities continually widen the gap, thereby weakening the short and medium term statistical position. World stocks of brimstone are estimated to have risen to six million tons.

The Sulphur Industry of Western Germany, the fourth largest in the world, consumed 1.2 million tons of sulphur in 1958 of which about 55% was imported. Domestic supplies consist of pyrites, spent oxide, recovered brimstone and by-product sulphuric acid. The German market represents to-day over two-fifths of the entire European pyrites trade. By basing sulphuric acid manufacture on the use of pyrites and by integrating this, over the past 75 years with the fullest possible realisation of the metal values of the pyrites residues, Germany is the key to the future of European pyrites. Of her sulphuric acid output of 2.7 million tons (100% H_2SO_4) nearly 0.6 million tons is by-product acid. There is no sign yet that brimstone might succeed in progressively desplacing pyrite as the source of sulphur for two million tons of sulphuric acid output but it is doing so in the non-acid sector where the pulp industry accounting for about 40% of non-acid sulphur use of 190,000 tons was based predominantly on pyrite. Current brimstone imports are about 70,000 tons annually nearly equal to domestic recovered output of which 46% is derived from coal gas and most of the balance from oil refinery gas.

The growth of **Recovered Sulphur Production in Canada** is determined by the rate of progress in the natural gas industry, notably in respect of gas exports to U.S.A. Natural gas reserves of 300 trillion cu. ft., one-third of which appears to be sour gas is estimated to contain 260 million tons of sulphur. Sour gas cleaning and sulphur recovery plant installed and firmly projected indicate the recovery in 1960 of nearly 700,000 tons and in 1962 of three million tons. The marketing of this output, which arises more than 2,000 miles from the nearest major centres of consumption, demands special pricing of transportation and of the product itself.

Production of **Sulphur in the United States** in the third quarter declined to 1.2 million tons due to exceptionally low Frasch sulphur production averaging only 350,000 tons per month. Apparent domestic sulphur consumption was only 972,000 tons, about 11% less than in the third quarter of 1957. Greater imports of Mexican sulphur at about 160,000 tons and apparent recovered sulphur sales of 138,000 tons aggravated this position for the Frasch industry. Intensive selling by the

Sulphur Export Corporation raised U.S. sulphur exports to 374,000 tons, 4% more than in the same period of 1957. Mr. C. A. Wight, as the new President of Freeport Sulphur Co., presents the now traditional end-of-year **Review of the U.S. Sulphur Industry in 1958.**

Mexican Sulphur production in the third quarter was maintained at its high level and amounted to 314,000 tons of which 92% was Frasch sulphur. Exports expanded to 306,000 tons in the third quarter notably to the U.S.A. Deliveries also increased in the home market, now 100,000 tons per annum met primarily by recovered brimstone and native ores. Pan American Sulphur Company is the third largest producer in the world and, enjoying considerable competitive strength provides two-thirds of Mexico's sulphur production and three-quarters of her exports.

The Pan American Sulphur Company at Jaltipan dome, mines brimstone contaminated by hydrocarbons. In order to supply a high grade product, the crude molten sulphur is purified in plant adapted to meet the special process needs economically.

The sulphur industry of the **United Kingdom** in the third quarter consumed only 202,000 tons sulphur in various forms, 10% less than in the third quarter 1957. Sulphuric acid production of 508,200 tons (100% H_2SO_4) was 7% lower and non-acid uses, on account of lesser activity in the rayon industry, was about 25% down. All consumers of sulphuric acid except plastics and agriculture used less than one year earlier. In the closing months of the year the effect of Government measures to boost industrial activity was becoming apparent and should lead to increased demand.

The Laporte Group, prominent chemicals manufacturers with assets of £11 million, is one of the leading sulphuric acid producers in the United Kingdom. The output of one-quarter million tons (100% H_2SO_4), originating in the works of three subsidiaries, meets manufacturing requirements including the rapidly expanding output of titanium dioxide pigment and leaves a surplus for sale.

The Sulphur Industries in the Communist countries are being expanded under ambitious plans in order to raise sulphuric acid output and to promote adequate fertilizer supplies. Available sulphur resources are being brought into production notably the sulphur ore deposits in the Ukraine, Central Asia and Poland, pyrite in Bulgaria and non-ferrous smelter gas and anhydrite in East Germany. Emphasis on fertilizers not dependent on sulphuric acid is evident both on account of acid supply being limited and also for technical processing reasons.

San Telmo Iberica S.A. is expanding her mining and treatment facilities for the supply of cupreous, iron and flotation pyrites. The present output is about 50,000 tons pyrites which being low in arsenic finds favour both in domestic and export markets.

The Sulphur Industry of West Germany

IN COMMON with most industrial countries the chemical sector of West Germany has grown more quickly since the war than any other branch of her industry. Thus overall industrial activity in mid-summer of 1958 stood 90% above the pre-war level, whereas chemical production was 136% greater. War damage and to a lesser extent dismantling took their toll of plant capacity. The developments, however which exerted more influence than any other on the chemical industry were the dissolution of the I.G. Farben empire and the separation of the old-established chemical complexes of the Rhine valley and the Ruhr from those in present-day East Germany and West Poland which were largely complementary to those in the Western half of the former "Reich."

PRODUCTION INDEX
1938 = 100

	Chemical Industry	*Inorganic Chemicals*	*Organic Chemicals*
1948	55	63	94
1953	142	147	197
1954	160	170	207
1955	181	187	231
1956	198	198	253
1957	222	241	279
1958 (Jan. to Aug.)	236	217	276

But for the need to develop fresh technical and often also administrative organisations, coupled with the enforced delay in enlarging a number of industrial key activities—notably oil refining—overall expansion in chemicals might well have been greater and possibly even comparable with the overall development of the chemical industries of Italy, United Kingdom, Canada and Austria, where the chemical output has trebled, or in the United States, where it showed a fourfold increase over the pre-war level.

The spectacular post-war recovery and expansion in West Germany's chemicals sector as a whole is fully reflected in her sulphur industry, which to-day is the largest in Western Europe, having pulled ahead of the U.K. Sulphur industry some two years ago.

Sulphur production totals about 560,000 metric tons, consisting of recovered elemental sulphur, sulphur in pyrites and spent oxide and by-product sulphuric acid manufactured from coal and oil derived hydrogen sulphide and from sulphur dioxide in metal smelter gases. Sulphur consumption in all forms reached the highest level on record in 1957 when it totalled nearly 1.2 million metric tons.* The industry heavily depends on foreign sources of sulphur needs and only about 45% of her sulphur needs are met from domestic resources. In contrast to the United Kingdom whose sulphuric acid industry abandoned the predominant use of pyrites nearly 20 years ago or in the acid industries of some of her Continental neighbours where this occurred about as many months ago, West German sulphuric acid manufacture remains to date firmly and overwhelmingly wedded to the use of pyrites. The physical and financial integration of sulphuric acid manufacture and the utilisation of pyrites residue at extraction plants, of which the world renowned Duisburger Kupferhütte is the largest and most important, has placed the costing of sulphur in pyrites on an entirely different economic plane and removed many factors which in a direct comparison of brimstone and pyrites have especially recently, weighed so heavily in favour of the former.

* All quantities referred to in this article are in metric tons.

PRODUCTION

In 1957 West Germany's sulphur production totalled approximately 560,000 tons and was represented by recovered elemental sulphur (11%), pyrites (43%), spent oxide (8%) and by-product sulphuric acid derived from hydrogen sulphide extracted from coal gases and SO_2 in metal smelter gases (35%). In 1958 domestic sources of supply were augmented by the arising of copperas in titanium dioxide manufacture and some 18,000 tons sulphur equivalent was recovered and used in sulphuric acid manufacture. Anhydrite or gypsum which owes its place amongst useful sulphurous raw materials to the development in the early 1920's of Müller and Kühne at Farbenfabriken Bayer at Leverkusen, is not at present used in West Germany.

Over the past 10 years indigenous supplies have grown by nearly one-quarter million tons or 75% and even compared with those for the whole of Germany in the late 1930's, the current level of sulphur production and recovery in West Germany is about 25% greater. The main development that is now taking place is the growth of recovery of brimstone at oil refineries which is expected to double with the next three to four years.

Pyrites

Production in West Germany is based on the extensive zinciferous pyrite and zinc blende deposits in Westphalia, and small iron pyrite deposits in the Oberpfalz. In 1957 total pyrite production totalled 605,000 tons containing about 241,000 tons sulphur, but in 1958 output results are likely to be 5-8% lower. Peak production was achieved during the war and in 1943 domestic pyrites mines supplied 1.33 million tons pyrites containing about 526,000 tons sulphur.

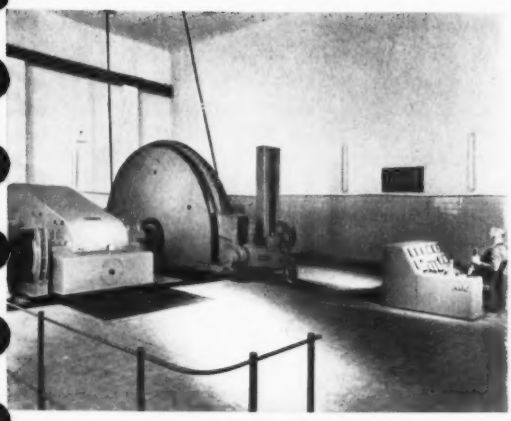
Sachtleben A.G. für Bergbau und Chemische Industrie. The company exploits the pyrites deposits at Meggen (Westphalia) and through its subsidiary those in the Oberpfalz. At Meggen the ore occurs in seams of pyrite which is generally accompanied by zinc blende and at times also by galena. The average composition of the deposit is as follows:—

Pyrite	72.35%
Zinc blende	12.32%
Galena	0.58%
Copper pyrite	0.06%
Baryte	0.34%
Matrix	14.35%

The pyrite is intimately associated with gangue and in consequence the sulphur content of run of mine ore is only 42% to 43%; other constituents are about 33% Fe, 8%-9% Zn., 0.06% As. The Meggen ore treatment plant consists of a crushing and screening installation which separates the ore throughput to yield fines of 0-4 m.m. or 0-6 m.m. and lumps of 20-30 m.m. and 30-50 m.m. Ore treatment is centred on a Wemco/Lurgi sink and float installation. Built in 1936, in the light of experience gained at the company's own pilot plant, the flotation plant has since then been expanded several times and brought up-to-date in line with modern developments. At present it has a daily throughput capacity of 300 tons crude ore yielding a zinc concentrate containing

Meggen Pyrites Mine. View of Headframe.

48-50% zinc and a tailing of flotation pyrites with a low zinc content. Before long this plant is to be expanded to yield daily 500 tons of pyrites flotation concentrate enriched to 48% sulphur. Pyrites from storage is despatched exclusively by rail by way of the company's own marshalling yard. Pyrites production at Meggen has been carried on for over 100 years. Before the First World War production rose to 200,000 tons and in the inter-war years about 360,000 tons annually. Peak output occurred in 1943 when 1¾ million tons was produced, but the present output, related to the qualitative requirements of the sulphuric acid and residues industry, is at a level of one-half million tons,



Control Room at the Meggen Mine.

representing about one-quarter of total German pyrites demand.

Bergbau-Gesellschaft m.b.h. Bayerland at Pfaffenreuth, near Waldsassen, operate a small deposit consisting of two adjacent irregularly shaped lenses. They contain magnetic iron pyrite, magnetite and in addition to small quantities of galena also some zinc blende and copper pyrite. Recently flotation facilities have been installed with a view to beneficiating the ore and raising the sulphur content. Output is 60,000 tons annually and is delivered predominantly to consumers in South Germany because of the low cost of freight. The movement of ore from mine to rail is done by lorry, the actual loading into rail waggons is by conveyor belt.

Sulphur Recovery

Nearly three-fifths of West Germany's indigenous sulphur supplies are recovered and derived almost exclusively from the desulphurisation of coal, oil refinery and metal smelter gases. It is estimated that in 1958 the equivalent of about 320,000 tons of sulphur was thus provided.

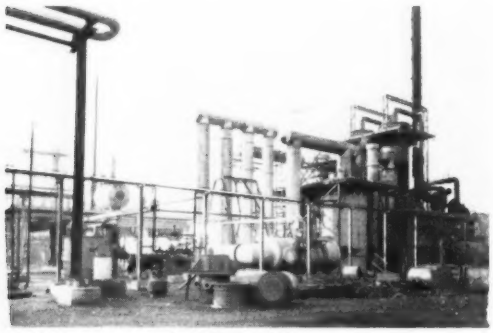
Thousand Tons Sulphur equivalent	*1948*	*1953*	*1957*	*1958 (Est.)*
Recovered brimstone	18	63	78	80
Sulphur in :—				
Spent oxide ...	20	36	46	45
H_2S for acid ...	15	25	42	45
SO_2 for acid ...	80	128	153	150
Total ...	133	252	319	320

Smelter Gases : The old-established metal smelting industries supply nearly one-half of recovered sulphur supplies in the form of by-product sulphuric acid and the resultant output of 450,000 tons (100% H_2SO_4) is surpassed only in Belgium, U.S.A., U.S.S.R., and Japan. There are six individual producers : Norddeutsche Affinerie at Hamburg, Unterharzer Berg-u. Hüttenwerke at Harlingerode and Oker (Harz), Stolberger Zink A.G. at Nievenheim, Berzelius Metallhütten G.m.b.H. at Duisburg-Wanheim, Metallwerke Unterweser A.G. at Nordheim and A.G. des Altenbergs Für Bergbau u. Zinkhüttenbetrieb. Zinc and copper smelting yields most of sulphurous exit gases, but the SO_2 of lead and tin smelter exit gases is also utilised. Norddeutsche Affinerie at Hamburg, widely known for its great scope in metallurgical activities, alone accounts for about one-quarter of total by-product acid output. In addition to the production of contact acid from copper smelter and convertor gases, some 1,800 tons liquid SO_2 is produced annually by the Sulfidin process and up to 6,000 tons contact acid is recovered from sludges in a Miley retort. The other metal smelters confine their activities to the production of various grades of contact acid. Apart from limited quantities used in situ for metallurgical purposes, there is practically no integrated acid usage and the output is sold. The intimate association of Metallgesellschaft of Frankfurt with several of the metal smelters has resulted in a large proportion of by-product acid sales being effected by this company.

Coal Gas :

The purification of coal gas at town gas works and more significantly at coke ovens has reached in Germany a higher level of efficiency and diversity of processing and end-products than in any other country's coal industry. This intensive approach to the desulphurisation problem is largely occasioned by the activities of Ruhrgas A.G., which, founded in 1926, collects by way of high pressure gas grids, the gas output of the Ruhr coke ovens and coal gasification plants and distributes it to industry. Its grid, extending over about 2,000 kilometres, covers the whole of the Ruhr and links up with gas mains serving the Rhine Valley, the Saar and ultimately the Lorraine. Gas purification is effected under the control of individual works who select amongst others the method of desulphurisation best suited to their specific needs. Both wet and dry purification play their

part in removing sulphur present mainly as H_2S, from the gas stream. The most common method is wet purification to remove the bulk of H_2S, followed when necessary by dry purification to deal with the remainder. Wet



Wet catalysis acid unit at Dorsten based on H_2S recovered at Alkazid installation, and forming part of the complete gasification plant.

purification by the Alkazid process of Badische Anilin & Soda Fabrik, the hot potassium carbonate process of Koppers of Essen and preferential adsorption of H_2S by ammonia as applied by Collin, Ibing, Pintsch-Bamag and others are most prominent, whereas in dry purification, natural and synthetic ferric oxide —the latter under the name of "Luxmasse"— have recently been supplemented by pelletized iron oxide in a process developed by Gastechnik m.b.H. of Oberhausen. Concentrated H_2S is converted on site to sulphuric acid in wet contact sulphuric plants, the majority designed and constructed by Lurgi Gesellschaft Für Chemie und Hüttenwesen, Koppers and Chemiebau Dr. Zieren, or it is burnt to SO_2 and converted to elemental sulphur in a Claus kiln. To promote the most economic use of the large volume of spent oxide, Ruhrgas A.G. operate two central sulphur recovery plants at Horst and Herten where, by solvent extraction and filtering, high purity brimstone is produced. A similar although smaller plant is operated by Thyssensche Gas und Wasserwerke at Hamborn. These two producers together with recovery plants at four coke ovens plant and at the Mainz gas works, each recovering only 500-2,500 tons per annum sulphur in Claus kilns, provide about 37,000 tons, equal to 46% of West German elemental sulphur output. Even so under one-half of the sulphur extracted from coal gas by dry purification is recovered in elemental form, the rest of it arising as spent oxide with 42-49% sulphur is burnt and converted to sulphuric acid. In 1957 this amounted to some 46,000 tons sulphur contained in about 110,000 tons spent oxide.

By-product sulphuric acid manufacture from H_2S is a feature of almost every major coke-oven plant and although none have an installed capacity in excess of 50 tons per day (100% H_2SO_4) the output of about 32 plants adds 100,000-120,000 tons acid a year to West Germany's supplies. The bulk of this output which arises mostly as 60° Bé acid is used in making ammonium sulphate from by-product ammonia.

Oil Refineries:

The contribution of West Germany's petroleum industry to sulphur supplies which in 1958 is estimated to amount to about 40,000 tons is on the verge of rapid expansion. Oil refinery capacity is being boosted and the range of operations is being brought in line with the most up-to-date refinery practice. This entails from the point of view of sulphur extraction increasing emphasis on desulphurisation of gas and diesel oils whereas hitherto only the main refinery exit gases—predominantly originating in the "cat cracker"—were so treated.

At present sulphur extraction from refinery gases and recovery is being carried out by Shell at Hamburg and Hohe Schaar, Esso at Hamburg, Mobil at Bremen, British Petroleum at Hamburg, Scholven Chemie at Gelsenkirchen and Gelsenkirchen Benzin refineries. Expansion at most of these plants and additional recovery units—being built at D.E.A., Purfina and Deurag refineries and by the natural gas producers in the Emsland—are expected to bring sulphur extraction and recovery capacity up to about 75,000 tons per annum in 1960.

Other Sulphur Recovery:

At the Hönningen works of Kali Chemie A.G., the important fertilizer and chemicals manufacturer, about 5,000 tons per annum of sulphur is recovered from by-product H_2S. Quantities up to 1,000 tons per annum each arise at the Oppau works of Badische Anilin & Soda Fabrik in the course of cleaning process gases and also at some of the carbon disulphide makers and users.

CONSUMPTION

The rapid post-war growth of West Germany's chemical industry was accompanied

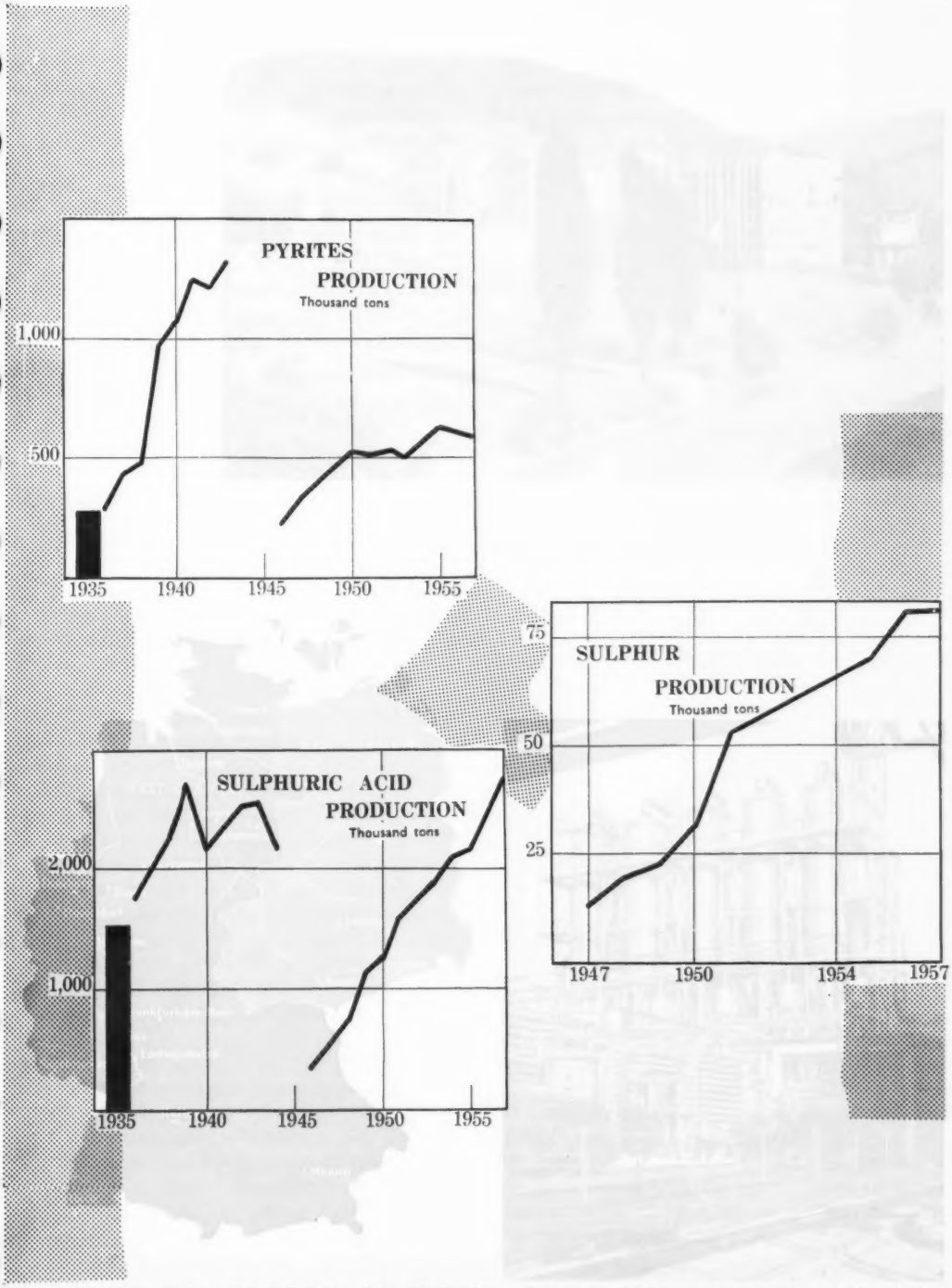


Fig. 1. Sulphur, Pyrites and Sulphuric Acid Production. Top right background; Sachtleben A.G., mining installations at Meggen; bottom right, Union Rheinische Braunkohlen Kraftstoff A.G., Alkazid desulphurisation plant at Wesseling.

by the expansion of sulphur demand which in 1957 reached 1.19 million tons, more than double that of 1938, and the highest on record. Preliminary data indicates that in 1958 these results might be surpassed by about 4% and raise West German sulphur consumption in all forms to 1¼ million tons. Of this total about 85%—equal to one million tons sulphur—is used to meet the needs of the sulphuric acid industry, which tends to overshadow the part played by the other sulphur using industries. Wood pulp and man-made fibres both hold prominent positions amongst European producers.

The raw materials supply picture of the West German sulphur industry remains dominated by pyrites which in 1957 represented about 70% of total usage and in 1958 fractionally less. Pyrites use has been preponderant not only in the manufacture of sulphuric acid but also, in common with other Continental countries, in the wood pulp industry; in this sector, however, the use of brimstone has recently made inroads, a development which, by and large, sulphuric acid has to date resisted. At present brimstone consumption is practically confined to the non-acid sector which in 1958 accounted for about 100,000 tons which was less than in the preceding year on account of the recession in the rayon industry. The sulphuric acid industry uses no more than about 15,000 tons brimstone. Spent oxide use on a modest scale is widespread and matched to local conditions. The biggest impact on the consumption in 1958 has been the need to accommodate the high level of by-product smelter acid which rose to 450,000 tons, equal to 150,000 tons brimstone, whilst the greater amount of sulphuric acid recovered at coke ovens correspondingly reduced the industry's primary acid needs.

Non-Acid Sulphur :

With an annual consumption of about 190,000 tons sulphur, West Germany's non-acid sulphur users are amongst the largest in Europe. Manufacture of carbon disulphide represents about 40-45%, closely followed by the pulp industry whose consumption is about 40% of total non-acid sulphur usage. Other industrial sectors are estimated as follows :—

Rubber	5½ %
Pharmaceuticals & Insecticides	3 %
Dyes & Pigments	3½ %
Paper	2 %

With the exception of the bulk of sulphur used by the pulp industry which consumes pyrites, West Germany's non-acid industries consume brimstone from domestic and overseas sources. In view of the favourable grinding properties of coal derived recovered sulphur, almost the entire supplies of ground sulphur to home and export markets are based on this source.

Wood Pulp :

One of the major European pulp producers, the West German industry confines its activities almost exclusively to the manufacture of mechanical pulp and sulphite pulp, the latter including dissolving, bleached and unbleached grades. In 1958 output of sulphite pulp receded about 4% from the previous year's peak figure of nearly 700,000 tons, a level of output more than double that in 1948.

Zellstoff Fabrik Waldhof is still the largest pulp maker in Germany and one of the largest in Europe, despite the loss of a large proportion —16 out of 22— of the company's installations which are in East Prussia and East Germany. Sulphur needs, estimated at nearly 30,000 tons annually, are met in the form of pyrites and liquid SO_2 and although the company now no longer owns the Stordo Mine in Norway, a nationalised concern since 1945, it still endeavours to obtain a large part of its pyrites supplies from this source. More than one-half of Germany's rayon cellulose output originates from the plants at Mannheim, Kostheim, Kelheim and Wangen. The intimate relations between the company and the rayon industry has found expression in the special rayon testing laboratories which are set up in Mannheim for the purpose of developing pulp grades to meet the rayon industry's special needs. An important achievement in this field has been the development of a cellulose from beech wood.

Aschaffenburger Zellstoffwerke : The almost exclusive use of pyrites for SO_2 manufacture is giving way to brimstone burners at two of the company's four plants when the present reorganisation scheme is complete in the course of 1959.

Schwäbische Zellstoffwerke Ehingen and several (six to seven) smaller works use mainly pyrites, including Jugoslav and Bayerland ores and occasionally take in local spent oxide supplies. In view of the strong selling pressures

some changes to brimstone use have already taken place or are imminent.

Carbon Disulphide :

As the result of the 17% decline in the rayon industry, affecting both staple fibre and filament sectors, production of CS_2 in 1958 was substantially lower than in the preceding year. Installed capacity in this sector is estimated at about 87,000 tons annual brimstone consumption. Manufacturers are :—

Chemische Fabrik Dr. Jacob at Bad Kreuznach
Süd Chemie at München
Chemische Fabrik Billwärder at Hamburg
A.G. Für Chemische Industrie at Gelsenkirchen

All four manufacturers sell their output of CS_2, their principal clients being the viscose rayon and transparent paper makers. Glanzstoff-Courtaulds A.G. of Cologne are reported to be giving consideration to the construction of an integrated CS_2 plant to meet their works needs. A plant based on brimstone and methane use, presumably by the Food Machinery Corporation, has been mooted.

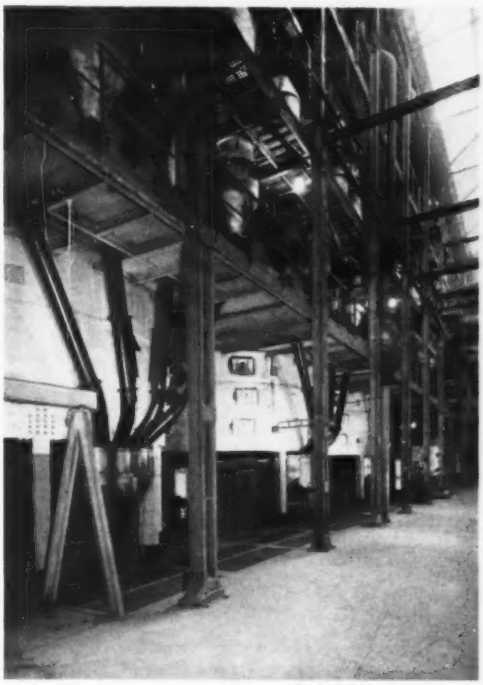
Other uses:

Ground and refined sulphurs meet practically all the remaining non-acid requirements of which the rubber and the sulphur export sectors are the most prominent. Activities are centred on Hamburg, where notable grinders and refiners are Biesterfeld & Co. A.G. Remy and Chemische Fabrik Billwärder.

Sulphuric Acid :

Founded in the first decade of the nineteenth century, Germany's sulphuric acid production rose to about 100,000 tons per annum by 1880, three-quarter million tons by 1910 and exceeded one million consistently in the late 1920's. Peak production, not even surpassed during the war, was attained in 1939, when 2.7 million tons (100% H_2SO_4) was produced. It is estimated that at the end of World War II about three-quarters of capacity installed was situated in territories which became West Germany and one-quarter in East Germany. By 1950 the level of acid production of the mid-thirties was reached and by 1954 the peak war-time figures were surpassed in West Germany where in 1957 output totalled 2.7 million tons (100% H_2SO_4).

Whilst the general production level has risen sharply the proportion of chamber and tower acid has contracted. In 1934 about 47% of German production was contact acid, a ratio which grew to 60% by 1939. Despite the rapid post-war rehabilitation of several tower plants and a number of new Petersen installations, in 1952 two-thirds of West



Farbenfabriken Bayer. Hearth Roasters at Leverkusen.

Germany's acid output originated from contact plants, and to-day their contribution is nearer 80%. Installed capacity is estimated to-day at three million tons provided by some 37 sulphuric acid producers.

The outstanding feature of West Germany's sulphuric acid industry is the concentration between three manufacturers—the successor companies of the I.G. Farben—of nearly 60% of the sulphuric acid output and about 75% of manufactured, as opposed to by-product, acid supplies.

The post-war reconstruction of the industry was accompanied by important modernisation and the installation of much new plant. Perhaps the greatest impact was caused by the development by Badische Anilin & Soda Fabrik of the Turbulent Layer roaster which it is estimated now accounts for over one-quarter of the installed capacity and represented by 30 individual units.

FARBEN FABRIKEN BAYER

Following the company's early developments in the latter half of the nineteenth century as manufacturers of natural and coal tar dyestuffs and pharmaceuticals, the emphasis between the World Wars shifted to basic inorganic chemicals and organic intermediates. As suppliers of basic and auxiliary materials Bayer assumed a vital rôle to a wide range of industries including fertilizers, paints, textiles, electric appliances, leather, detergents, rubber, paper and man-made fibres, and this was strengthened after World War II. In respect of sulphuric acid the plant capacity at Leverkusen, Uerdingen and Dormagen rose between 1952 and 1956 from 560,000 to 735,000 tons (100% H_2SO_4) annual capacity, making Bayer one of the largest acid producers in the world. Current capacity is 780,000 tons per annum of which 60% is represented at Leverkusen and 20% each at Uerdingen and Dormagen. Sulphur needs are met by pyrites of which 80% are imported and 20% obtained as indigenous zinciferous pyrites. In addition some 18,000 tons sulphur annually is recovered in the form of SO_2 obtained from the roasting of copperas. At present about 180,000 tons $FeSO_4$ $7H_2O$ is roasted in a Turbulent Layer roaster to the monohydrate which is in turn roasted to provide the requisite SO_2 for acid production. A variety of roasting plants are in use, particularly at Leverkusen where about one-quarter of installed capacity is still in the form of old-fashioned, though still efficient, lump burners, a similar volume as kilns, one-third as hearth burners and one-sixth as Turbulent Layer roasters. At Uerdingen operations are wholly based on hearth furnaces whereas at Dormagen these account for only one-third and two-thirds of capacity are Turbulent Layer roasters. As indicated below the company is prominent in the promotion of steam recovery from hearth furnaces and it is expected that the heat recovery of the two projected units will be within 10% of that of Turbulent Layer roasters without, however, incurring the penalty of the arsenic problem in the residues.

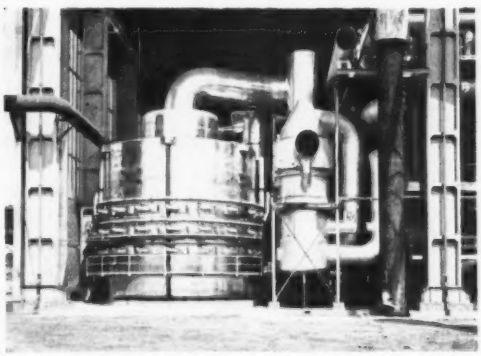
Bayer sell only 20% of the acid output. Of the integrated use about three-eighths is used in chemicals manufacture and a similar tonnage in titanium dioxide pigment production. Fertilizers (ammonium sulphate and superphosphate) account for only 12% whereas textiles, notably rayon, use 8% and a miscellany of products also 8%.

BADISCHE ANILIN & SODA FABRIK

The company's present-day eminence in a wide range of organic and inorganic chemicals —amongst which nitrogen fertilizers, dyes and

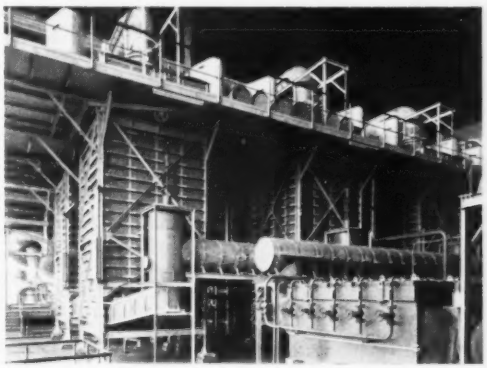
Farben Fabriken Bayer. Turbulent Layer Roasting Plant at Dormagen.

plastics are outstanding– derives from a policy of development work and research. Achievements in synthetic dyes, ammonia synthesis (Haber-Bosch), coal hydrogenation, contact sulphuric acid, are only a few of the chemical processes which owe their origin to Badische Anilin & Soda Fabrik. The vast works, the most extensive in Europe, at Oppau and Ludwigshafen on the West bank of the Rhine, include plant which makes the company the second largest sulphuric acid manufacturer in West Germany. The development by Badische Anilin & Soda Fabrik of the Turbulent Layer roasters coincided with the extensive modernisation plans and the need for replacement of old equipment and at present 84% of the company's annual plant capacity of 530,000 tons (100% H_2SO_4) is represented by Turbulent



BASF Contact Unit at Ludwigshafen

Layer equipment including a twin 250 ton per day plant, one of the most modern in the world. Hearth furnaces and kilns account for about 8% of Badische Anilin & Soda Fabrik pyrites roasting capacity. All convertors are now equipped with BASF's own system of cold air mixing jets and high reactivity vanadium catalyst also developed and produced by BASF and yielding 98% conversion in continuous operation. The wide range of the company's products demands that about 90% of total acid output is integrated and only special acid supplies are for sale. About 50% of the company's acid use is turned to fertilizer manufacture, about 20% to inorganic chemicals and 10% each for dyestuffs (Alizarin and Azo dyes) and organic intermediates manufacture, respectively. In Nitrophoska, the company's compound fertilizer, the rock is acidulated and solubilised by means of nitric and not sulphuric acid and the entire consumption of sulphuric acid in the fertilizer sector is in ammonium sulphate. The development of the Turbulent Layer roaster has resulted in the installation



BASF wet precipitators.

outside Germany of 72 units with an aggregate daily roasting capacity of about 4,600 tons ore and more are at present being planned.

FARBWERKE HOCHST A.G.

Playing a major part in the growth of Germany's chemical industry, the company's organisation and associations bear testimony to the purposeful diversification of processes and products. Production of dyestuffs, pharmaceuticals, solvents, plastics, inorganic and organic chemicals and intermediates, pesticides and phosphatic and nitrogenous fertilizers, industrial gases is divided between the works at Höchst, Gerstthofen, Griesheim, Knapsack and Kalle.

Sulphuric acid capacity of about 383,000 tons per annum (100% H_2SO_4) is based on pyrites, but at Höchst there is also a major stand-by brimstone burner which is used as required. Relatively little sulphuric acid is directed into fertilizer manufacture as phosphoric acid at Knapsack—one of the most economic producers in the entire European industry—is derived by thermal and not by chemical means.

Other notable producers are to be found amongst the producers of superphosphate who in the Spring of 1958 associated in the Superphosphat Industrie Gemeinschaft, a cartel conforming with German law. Chemische Werke Rendsburg, a company closely associa-

ted with the Hamburger Kupferhütte Ertel Bieber & Co., meets much of the fertilizer demand in Schleswig Holstein. Chemische Fabrik Kalk at Cologne is, in addition to making superphospate, an important nitrogenous fertilizer manufacturer. Süd-Chemie at Kelheim is the leading chemical and fertilizer manufacturer of Bavaria. Guano-Werke A.G. operates fertilizer plants at Lübeck, Krefeld and Fienburg and is now an integral part of the WASAG Group. It is associated with WASAG's new project Stickstoffwerke Krefeld, where the by-product gypsum from Guano-Schwefel Säure A.G. at Bochum, and Chemische Fabrik Curtius A.G. Essentially serving the nitrogenous fertilizer industry for ammonium sulphate production the companies' operations are noted for exceptionally economic working especially in respect of raw materials use and keen integration of by-product acid supplies. Derived from metal smelters and coke ovens these play a major part in Germany's acid supply and fertilizer production.

Sulphuric Acid Consumption

Fertilizers, and particularly ammonium sulphate, account for the lion's share of West

Süd-Chemie. General view of the third 150 tons per acid plant at Kelheim completed in 1957.

werke's phosphoric acid manufacture is due to provide the sulphur radicle of Stickstoffwerke's ammonium sulphate output which will be made by the direct carbon dioxide method. Chemische Werke Albert at Wiesbaden, Kali Chemie at Hanover and works at Hönningen and Gebr. Giulini at Ludwigshafen together with six lesser producers make up the full membership of the association.

Of major importance are the sulphuric acid plants serving the Deutsche Ammoniak Verband which are grouped under Ruhr German sulphuric acid use. Representing 43½% in 1957, this industry's share has in recent years fluctuated between 40%-44% with ammonium sulphate representing 34%-35% and superphosphate claiming 9%-10%. Textiles, predominantly man-made fibres, represent about 12% of total use although none of about 340,000 tons (100% H_2SO_4) so used is manufactured by the industry but bought in, with Farbenfabriker Bayer as the largest suppliers. A departure from this practice is the decision taken in July 1958 by Glanzstoff-

Courtaulds of Cologne to build a small sulphuric acid plant. Production will be based on elemental sulphur; the plant, a contact installation now on order from Chemiebau Dr. Zieren is due to come on stream towards the end of 1959. Titanium dioxide manufacture consumed about 20,000 tons per month of

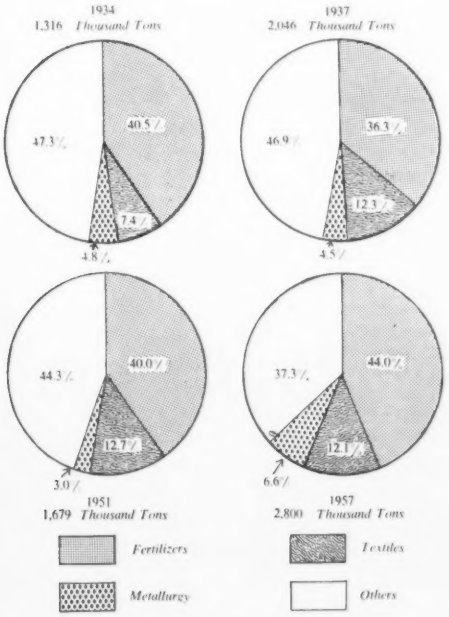


Fig. 2. Sulphuric acid consumption

sulphuric acid since the completion of Titan A.G.'s plant last year. Metallurgy, detergents and dyes manufacture are major industrial acid users, whereas the wide range and heavy volume of chemicals makes this category the second largest, about 900,000 tons annually, representing about 32% of total use.

Pyrites Residues

West German pyrites supplies fall broadly into three categories: (a) indigenous zinciferous pyrites (b) imported non-cupreous iron pyrites (c) imported low and high cupreous iron pyrites and copper pyrites. The utilisation and, if appropriate, the treatment of the pyrites residues is conditioned by their composition. Non-cupreous iron pyrites and concentrates are, owing to the absence of non-ferrous metallic impurities, suitable as direct blast furnace feed and in Germany these are sold direct to the iron makers. In this group the very pure Montecatini residues, which compare with high grade iron ore, are an outstanding example. The zinciferous Meggen residues are in part treated by the parent company for the extraction of zinc oxide and manufacture of lithopone or they are supplied to a residues treatment plant and form a part of the feed. Cupreous iron pyrites and copper pyrites are the basis of cinder treatment and extraction which ranges in accordance with individual treatment plants, interests and capablities.

The integration of sulphuric acid manufacture and the utilisation of pyrites residues is the linchpin of West Germany's sulphur industry and on its existence the European pyrites industry has expanded to prosperity and now depends for its survival. There are in West Germany three treatment plants: Hochofenwerk Lübeck, Hamburger Kupferhütte Ertel Bieber & Company, both confining their activities to copper extraction and smelting and pig iron production, and Duisburger Kupferhütte; the last named in view of its size, versatility of residue treatment facilities and range of product end is the most important of the three.

This enterprise was established by the German sulphuric acid industry for the specific purpose of reducing its net cost of sulphur by realising fully the metal value of residues by recovering, in addition to iron, the multiplicity of non-ferrous and precious metals. Spanish pyrites, as in the past, form the basis of the residues intake, but other residues of varying origin such as Portugal, Norway, Cyprus, Cuba, Canada, Turkey, Finland each play their important part in providing a balanced supply. Of the DM. 42 million share capital of Duisburger Kupferhütte, 30.17% is owned by each of the three I.G. successor companies and the balance by four lesser companies who are concerned in the Kupferhütte activities. It is estimated that the recovery of metals and by-products represents a value of about DM. 140 million. The desired level of Duisburger Kupferhütte operations is about 1.9 million tons residues throughput. In West Germany in 1957 total arising of residues was about 1.3 million tons and in consequence the efficient operation of the three pyrites residues plants

depends on imports, which in turn accounts for their concern in the maintenance of adequate overall European pyrites consumption.

It is appropriate in this context to examine the impact of this sector of the industry of the use of fluidised bed roasters and in particular the Turbulent Layer furnaces developed by Badische Anilin & Soda Fabrik. As a result of their exceptional operating economics their use has spread very rapidly in Germany where, as indicated above, some 800,000 tons per annum roasting capacity is now installed. Possibly their only major drawback in conjunction with the roasting of pyrites is that in the case of arsenical ores, the bulk of the arsenic content is not volatilised, as in the lower temperature hearth furnaces, but remains locked in the residue making it unsuitable as a blast furnace material. Two-stage fluidised roasting provides an answer to the technical side of arsenic removal but raises in turn other problems of heat recovery and economics of operation. The development of hearth roasters with steam recovery, both by Lurgi of Frankfurt and Klöckner-Humbolt of Cologne was undertaken to retain the advantageous features of the hearth roaster with regard to arsenic removal whilst making its economics compare with that of the Turbulent Layer roaster. Farbenfabriken Bayer envisage the installation in 1960 of two Klöckner-built 75 tons per day hearth roasters, the heat recovery of which has been established at 1 ton of steam per ton of SO_3 produced.

TRADE*

Pyrites

In 1957 pyrites imports into West Germany reached the highest ever level, totalling 1,502,000 tons and even greater than the exceptionally heavy imports in 1937 and 1938 when the raw materials stockpiling policy of the Reich attained its peak. Although there have been many changes in the pattern of supplies it is significant that Spain, with the exception of the actual war period, has continuously been Germany's largest supplier. Prior to World War I imports originated almost exclusively from the Iberian peninsula; in the 1920's and 1930's Spain, Norway and Cyprus were the main suppliers. Since 1945 the number of countries shipping substantial quantities has increased to seven or eight, but Spain's position of premier supplier is determined by the purchasing policy of the Duisburger Kupferhütte, who buys the sulphur in pyrites on behalf of its associated companies and retain the ownership of the residues. The greater diversity of supplies in recent years has been occasioned by the changes in the quality of Spanish pyrites, their lower copper content. Instead, cupreous pyrites from Cuba and Turkey as well as increased quantities from Cyprus meet the needs of a balanced residues mixture at Duisburger Kupferhütte and other treatment plants. This requirement provides a market for Finnish pyrites concentrates the residues of which carry interesting cobalt values. Up to three years ago Jugoslav pyrites reached South German acid makers and pulp mills in substantial quantities, mainly on account of their favourable transport route by Danube barges. Their decline is attributable to the greater attractions of Canadian pyrites concentrates and competitive pressure from the established suppliers to the German market. In 1958 the pattern of supply remained practically unchanged, but the existence of heavy stocks caused the level of imports to recede; it is estimated that in 1958 they will be 10% lower than in the preceding year, i.e. at about the level of 1956.

Brimstone

Despite the relatively low domestic needs of sulphur in elemental form and her substantial recovered brimstone output, Germany's import requirements have progressively grown in recent years to reach 64,500 tons in 1957 and probably 70,000 in 1958. The extent of imports is attributable to the expansion of Germany's export trade in ground and refined sulphur which are probably the most competitive European supplies in non-Commonwealth overseas markets. The higher level of brimstone of the late 1920's when it exceeded 100,000 tons annually was similarly coupled with a correspondingly higher rate of re-exports. Peak imports of brimstone occurred at the beginning of World War II when in 1941 they totalled 148,200.

The pattern of supplies has not undergone great changes. U.S. sulphur has remained the main source except for the war years when Italy became the sole supplier. Since 1951 Italian supplies have ceased altogether on account of their excessive cost but since 1955 Mexican filtered brimstone has contributed

* For further details see Statistical Appendix.

about 10,000-13,000 tons annually taking one-fifth of the market. Imports of French recovered sulphur totalling about 15,000 tons in 1958, mark the advent of a new era in the European sulphur market. At present the main importers are Messrs. Metallgesellschaft for United States sulphur, Huckfeldt and Co. for Mexican sulphur and Biesterfeld and Co. for French sulphur.

Sulphuric Acid

West Germany's sulphuric acid export and import trade with neighbouring countries has lost some of its significance in recent years. Germany's plant capacity has been increased to a level where it is more than adequate to meet the requirements. Total acid shipments from Belgium and occasional supplies from Holland contributed over 200,000 tons in 1952. Since the early 1950's the volume of sulphuric acid trade, which is largely in the hands of Metallgesellschaft of Frankfurt has decreased and in 1957 represented imports of about 100,000 tons and exports of 40,000 tons.

CONCLUSION

The importance of West Germany's sulphur industry is not to be found in its size, although it is the fourth largest in the world, but in the versatility and technique evident in its many sided operations which have been overriding factors in determining its favourable economics. One of these special features has been the unique position of pyrites resulting from the development of the sulphuric acid sector in concert with the utilisation of ferrous and non-ferrous metal values of pyrites residues in one of the earliest examples of an integrated chemo - metallurgical industrial complex, Duisburger Kupferhütte. For the first time since its formation over three-quarters of a century ago this link is in serious jeopardy. The threat originates from the rising world surplus of brimstone production and capacity particularly in the field of recovery. Germany's sulphuric acid sector is an attraction as it represents, in effect, an entirely new market for brimstone. Less direct but not less serious is the contraction of pyrites usage in other Western European countries who have in the past met Germany's, and in particular Duisburger Kupferhütte's, import needs of pyrites residues. Any deterioration in the comparative cost of sulphur in pyrites in relation to brimstone could start a trend which might form into a landslide if the intangible merits of brimstone usage found favour amongst acid makers. There is as yet no sign that this psychological change has occurred and beyond keeping a strict check on comparable overt costs the German acid industry still shows a united front in its preference for pyrites. Probably the greatest support for the maintenance of the prevailing consumption pattern is to be found in the close understanding between European pyrites producers and Duisburger Kupferhütte.

The outlook for the German sulphur industry is conditioned by the prospects of increasing consumption and in this respect none of the major uses show a clear trend. Ammonium sulphate output should advance in common with other nitrogenous fertilizer usage but it is exceptionally vulnerable to changes in world nitrogen markets. Superphosphate production tends to be limited by the rising level of basic slag supplies, whilst rayon production, is at present, at a low point and shows little signs of recovery. Titanium, despite the proposed threefold expansion to 50,000 tons titanium dioxide, may not increase acid needs as the supply in the near future of slag will change the materials balance in titanium dioxide manufacture. By-product acid supplies tend to grow and the expectations for the next five years point to a relatively slow expansion of primary sulphuric acid output, since overall demand is not now expected to show a net annual advance in excess of 2-3%.

The West German sulphur industry is nearing the cross roads and the decision whether or not pyrites will continue to dominate her supply pattern or whether she will become a major outlet for brimstone will affect the whole world sulphur picture. The main impact of brimstone will come from French recovered sulphur, especially now that the Common Market is in being, and will make itself increasingly felt after 1960. To succeed in securing a major share of the German market may require a reduction of brimstone prices which might have to be so great as to nullify the gain of the new outlet. The capital investment and the technical skills of Germany's sulphuric acid and pyrites residues treatment industries represent a powerful barrier against fundamental changes and this is being fortified by the pyrites producers efforts to retain this key market.

Recovered Sulphur in Canada

ALTHOUGH TO-DAY recovery of brimstone from natural gas in Western Canada has as yet made no great impact upon the world's total production, there are positive indications of the magnitude of future contributions that are likely to occur. Already Canadian imports of U.S. brimstone have been reduced by 40,000 long tons in 1957 due to the increase in home production of recovered sulphur to over 100,000 tons. The factor determining the expansion of sulphur recovery is the rate of natural gas sales. The basic expansion of a gas pipe network has been laid, but it is evident that rapid and profitable use of Canada's vast natural gas reserves are intimately linked with gas exports to Western U.S.A. The establishment of the Borden Commission to examine Canada's energy supply problem has been largely determined by the question of gas exports and it remains to be seen how the Government interprets the findings of the Commission which were published last October.

An important recommendation of the Borden Report was that the Commission must be shown that all practical steps had been taken to obtain markets for by-products resulting from the processing of natural gas, before exports of gas would be sanctioned. The Commission also suggested that as the United States will be an important market for these products, consideration should be given when granting or withholding gas export licences to the extent to which access is afforded to by-products in such a market. Therefore, in order that Canada's new wealth of sulphur may be brought into focus it is essential to investigate the natural gas industry in the light of the Commission's recommendation.

NATURAL GAS

Reserves

Reserves of natural gas in the Western Canadian Sedimentary Basin can reasonably be estimated at 300 trillion cubic feet. This figure has been arrived at after consideration of submissions to the Commission by numerous companies actively engaged in production or transportation of gas, and a report by the Oil and Gas Conservation Board of Alberta. Of this figure approximately 25 trillion cubic feet have been proved to date, but reports of strikes in new areas are frequent and it is estimated that a further 2 trillion cubic feet will be proved each year until 1970 with a further 1 trillion cubic feet for each successive year.

In Billion Cubic Feet

Field	Company Involved	Reserves as at 6/58	Extraction to Date	H_2S Content	Transportation	Initial Potential MMCF Per Day
East of Calgary	Socony-Vacuum Oil Co. of Canada	1,068	—	No Data	West Coast Transmission	No Data
Jumping Pound	Shell Oil Company	525	96.7	3.58%	Trans-Canada Pipelines	17.5
Nevis	British American Oil Ltd.	550	—	No Data	Trans-Canada Pipelines	8.0
Okotoks	Devon Palmer Oils Ltd.	135	0.9	34.4 %	Local Usage	1.0
Pincher Creek	British American Oil Ltd.	1,806	21.8	9.26%	Trans-Canada Pipelines	100.0
Savanna	Husky Oil & Refining Ltd. Northern National Gas Producing Company Phillips Petroleum Co. Canadian Anaconda Oils Target Petroleums [Ltd.	550	—	14.0 %	West Coast Transmission	51.0
Turner Valley	Royalite Oil Co.	2,116	1,750.8	1.12%	Trans-Canada Pipelines	22.0
Waterton Park	Shell Oil Co.	750	—	No Data	No Data	9.75
Dick Lake	Husky Oil & Refining Ltd.	No Data	—	1.25%	Alberta & Southern Gas Transmission	288.0
Total Reserves		7,500+	1,870.2	1.25%		

Producers

The main production area of natural gas is in Alberta, although gas is also present in Saskatchewan, at Steelman, in British Columbia on the Alberta Border in the Peace River Basin, and in Ontario and Quebec, where a meagre production has up to date been supplemented by imports from the U.S.A. by the Tennessee Gas Line.

Alberta: The proved reserves in Alberta as estimated by the Oil and Gas Conservation Board in January 1958 are 21 trillion cubic feet. Alberta's 30-year needs are estimated at 7.6 trillion cubic feet, with peak annual consumption of 334 billion cubic feet in 1987. It is further estimated that by wildcat drillings the initial disposal reserves will be increased to 42 trillion cubic feet by 1986. The following table contains only those fields whose gas possesses sufficient H_2S content to warrant sulphur recovery.

This total comprises approximately a third of the gas reserves in Western Canada, the remaining two-thirds being sweet gas, and therefore of no concern to the sulphur industry.

The rapidity of the expansion of the industry is emphasised by the fact that 42 successful new gas strikes were made in the year June '57/June '58, of which one at Berland River by Pan American Oils Limited has an estimated reserve of 2 trillion cubic feet.

British Columbia: Although there are 11 gas fields in British Columbia, only the Fort St. John field, which is part of the Peace River Basin, is of importance. This field has an estimated reserve of 3 trillion cubic feet, having already yielded 28.9 billion cubic feet. All the gas from this field is contracted to the West Coast Transmission Company for disposal

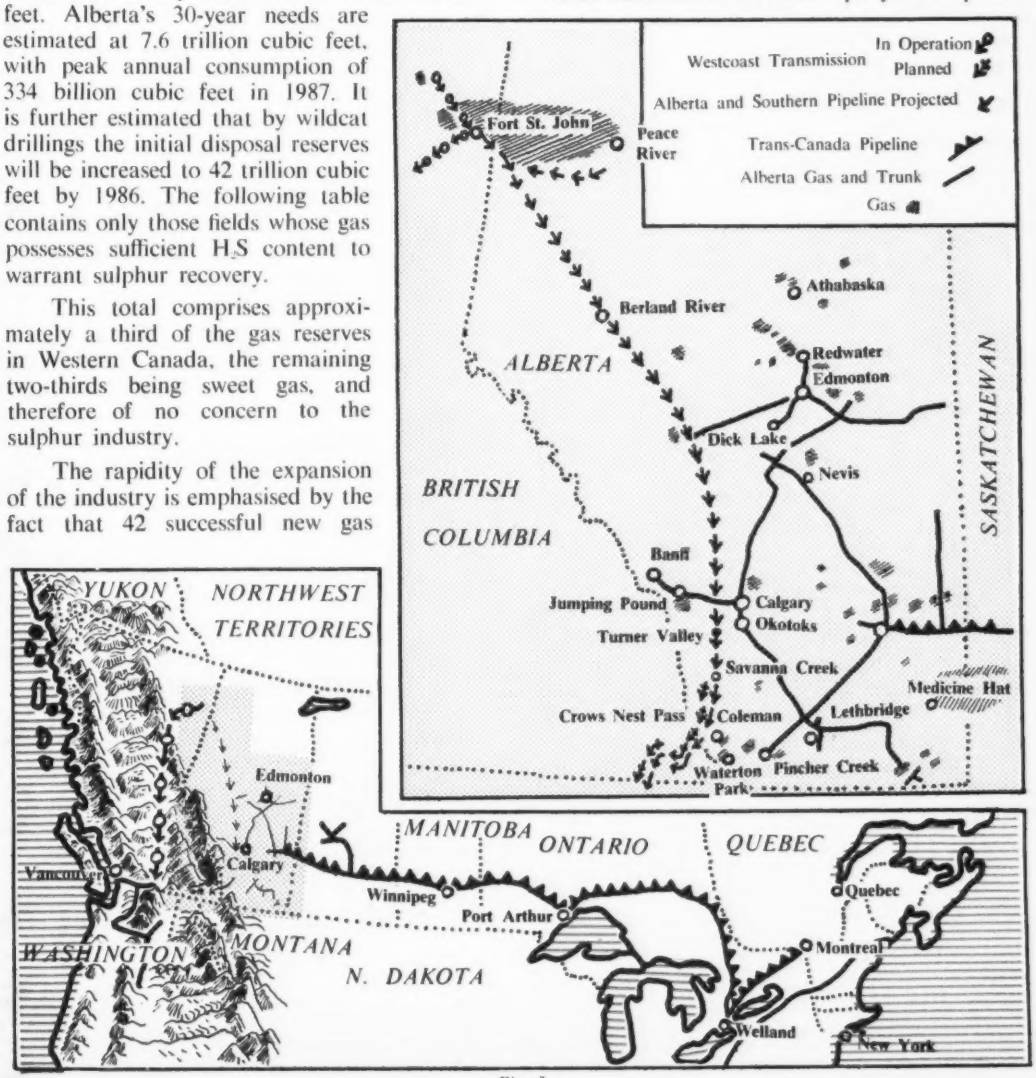


Fig. 3

in British Columbia and export to the U.S.A. However, as an indication as to how the industry is expanding, it is interesting to note that 10 successful wildcat drillings were made in the year June '57/June '58.

Saskatchewan: The Steelman field is the largest of the natural gas fields at present being exploited in Saskatchewan. It is intended that with the exception of a small percentage for local consumption, all the gas produced in Saskatchewan will be delivered to the Trans-Canada Pipeline. The proved reserves at January 1958 were 1.06 trillion cubic feet. The plant has an initial capacity rate of 25 million cubic feet per day with an ultimate design capacity of 45 million cubic feet per day.

Consumption

In view of the new found wealth of power and raw materials, new industries are likely to become established in Western Canada, but this added consumption will not greatly affect the surplus which could thus be made available for export to the United States.

The following table shows the Canadian market supply and demand for the next 30 years, based on Alberta natural gas reserves.

DEMAND 1958-1987

In Billion Cubic Feet

Year	*Total Canada*	*Cumulative Canada*	*Year-End disposable reserves (low)*	*Year-End disposable reserves (high)*
	(1)	(2)	(3)	(4)
1958	234.0	234.0	23,766	23,766
1963	558.0	2,512.6	31,487	31,487
1968	776.3	5,920.2	38,080	38,080
1973	1,009.8	10,513.4	40,486	43,486
1978	1,245.1	16,249.8	39,750	47,750
1983	1,494.4	23,226.5	37,774	50,774
1987	1,717.0	29,764.2	35,236	52,236

Estimated Canadian demand for Alberta natural gas shown in column (1) of this table is based on the higher of the two principal market forecasts of the requirements of Trans-Canada Pipelines Limited for the 30-year period. An average annual gas discovery rate of 2 trillion cubic feet through to 1970, followed by an annual rate of 1 trillion cubic feet to 1987, is assumed in Column (2). This is a conservative assumption. The reserves shown in Columns (3) and (4) represent high and low year-end reserves, after deduction for anticipated production.

Exports and Transportation

West Coast Transmission Company have applied for an export permit to extract from the two sour gas fields at Savanna Creek and East of Calgary, in the province of Alberta, a total of 1.3 trillion cubic feet over the next 25 years, of which they intend to export 1.297 trillion cubic feet to the North Western States of U.S.A., the remaining 3.5 billion cubic feet to be distributed to communities in Alberta and S.E. British Columbia.

West Coast Transmission already hold a permit to export gas from the Peace River area to the U.S.A. The pipeline, which has a capacity rate of 660 million cubic feet a day, joins that of the Pacific North West on the international boundary at Huntingdon, just East of Vancouver. They are contracted for 20 years to export 300 million cubic feet per day for each successive year after January 1959 at 22 cents per thousand cubic feet.

Alberta and Southern Gas Company Limited originally applied for an export permit to extract from the province of Alberta a total of 4.2 trillion cubic feet over a period of 25 years, which they intended to export, with the exception of small amounts for British Columbia communities, to the U.S.A., mainly in California and Montana.

Both these applications to the Oil and Gas Conservation Board of Alberta were refused on the grounds of magnitude, and in consequence both companies filed new applications in the first week of December 1958 to export a total of 625 million cubic feet per day, for a period of 25 years. Alberta and Southern Gas Company Limited have contracted to take part of their requirements from the Berland River fields.

Trans-Canada Pipeline Limited: This pipeline was completed on 10th October 1958 and is in the process of being filled. It starts on the Alberta/Saskatchewan border, near the town of Burstall, and extends through Manitoba and Ontario to Montreal, in Quebec, a total distance of 2,294 miles. The gas is obtained from the Alberta Gas and Trunk Line and delivered to all the main cities and towns in the provinces through which it runs. In addition to these deliveries to home consumers, it is intended to export gas to the Tennessee Gas Line, which it will join at Niagara, and also at a point near Emerson on the Manitoba/Minnesota border.

The initial delivery capacity of the pipeline will be 300 million cubic feet a day, and has been designed so that its delivery capacity can be increased in the future to 780 million cubic feet a day. Contracts have been made for a daily maximum of 620 million cubic feet and an annual maximum of 183 billion cubic feet to be supplied by gas producers in Alberta. The Province of Alberta has granted a permit extending to 1981 to export to the Eastern provinces a total of 4.35 trillion cubic feet via Trans-Canada Pipeline.

Alberta Gas Trunk Line Company Limited: This pipeline is a gathering system within the Province of Alberta for all gas to be exported to the Trans-Canada Pipeline. It extends to Edmonton in the North and Pincher Creek in the South, a total coverage of approximately 600 miles.

SULPHUR RECOVERY

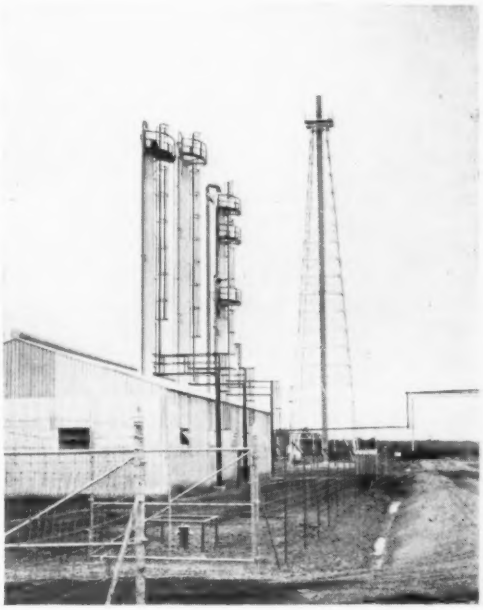
Since the commencement of sulphur recovery from natural gas in Canada in 1952, the production has risen from 8,900 short tons to 102,171 short tons in 1957. It is estimated that production for 1958 will approach 120,000 short tons.

The reserves of sulphur that could be recovered from the reservoir of natural gas at present being tapped are estimated at 40 million short tons, and from the ultimate reserves of natural gas estimated to exist in Canada, approximately 260 million short tons.

Producers

Pincher Creek: British American Oil Company, formerly Canadian Gulf Oil Company, who made the initial strike in 1947, completed their initial construction phase of the plant at Lethbridge in January 1957, which included a sulphur recovery plant with a capacity of 225 short tons per day. The second phase, completed in the summer of 1958, includes a further three sulphur recovery plants, each with a capacity of 225 short tons per day, giving an overall capacity of 900 short tons per day, or 297,000 short tons per year. It is likely that Pincher Creek production will be approximately 65,000 short tons for the year 1958. The estimated reserves are 8,000,000 short tons of high quality sulphur.

Redwater—Alberta: Imperial Oil completed their plant in 1956 and commenced sulphur production in December of that year.



Imperial Oil. Sulphur processing plant at Redwater showing fractionation towers.

The capacity of the sulphur recovery plant is approximately 10 short tons per day, although this is not being attained, production during the first nine months of 1958 being 1,299 tons. The H_2S content is 4.56% of the natural gas.

Fort St. John—Peace River Field—British Columbia: Jefferson Lake Petrochemicals of Canada Limited, which was formed by Jefferson Lake Sulphur Company of New Orleans who will retain 69% of the share capital, have

SUMMARY AND ESTIMATES OF PRODUCTION OF RECOVERED SULPHUR

In Short Tons

Name	*Capacity*	*Output*	*Estimated Output*		
		1957	*1959*	*1962*	*1965*
In operation					
Turner Valley	12,000	11,800	12,000	12,000	12,000
Jumping Pound	29,700	25,821	29,700	29,700	29,700
Redwater	3,300	2,490	3,300	3,300	3,300
Pincher Creek	297,000	56,660	297,000	297,000	297,000
Peace River Field	268,200	4,800	168,300	268,200	268,200
Okotoks	132,000	—	132,000	132,000	132,000
Steelman	3,300	—	3,300	3,300	3,300
Projected					
Savanna Creek	181,500	—	—	181,500	181,500
East of Calgary	130,000	—	40,000	130,000	130,000
Calgary Area	90,000	—	—	90,000	90,000
Nevis	100,000	—	—	100,000	100,000
Probable					
Berland River and Other Areas	1,250,000	—	—	750,000	1,250,000
Total	2,497,000	102,171	685,600	1,997,000	2,497,000

All Tonnage estimated on a working year of 330 days. The 1962 and 1965 figures are estimates, but the figure may be nearer 3 million tons than 2 million. Production at Savanna Creek depends on month of starting.

in production a sulphur recovery plant with a daily capacity of 510 short tons or 168,300 short tons per year. This plant came into operation in November 1957 and for the last two months of 1957 produced 4,800 short tons of sulphur.

There are plans to enlarge the plant in 1959, which will raise the annual production of sulphur to approximately 268,200 short tons. This expansion will cost $55 million.

Okotoks—Alberta: Devon-Palmer Oils Limited, in co-operation with Texas Gulf Sulphur Company, have just completed their gas cleaning and sulphur recovery plant, and production was due to start in December 1958.

Texas Gulf are to operate the sulphur recovery unit, and as the H_2S content of the gas is 34.4%, they expect to produce 400 short tons of sulphur per day, or 132,000 tons per year.

Savanna Creek—Alberta: Jefferson Lake Petrochemicals Limited with Phillips Petroleum Company have plans to construct a gas cleaning and sulphur recovery plant, with a daily capacity of 500 short tons, in the Savanna gas field in 1960.

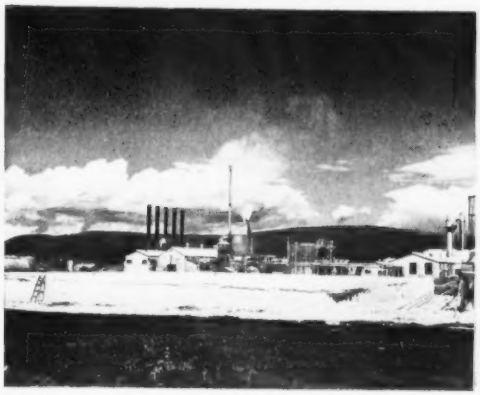
Turner Valley—Alberta: Royalite Oil Company began recovering sulphur from natural gas at approximately the same time as Shell Oil Company, but their capacity of 34 short tons per day or 12,000 short tons per year has remained unchanged. Production during 1958 was at an annual rate of 10,000 tons.

Royalite Oil Co. General view of natural gas processing and sulphur plant at Turner Valley.

Jumping Pound — Alberta: Shell Oil Company was one of the first companies engaged in the recovery of sulphur from natural gas and since 1956, after more than doubling the plant facilities, has been producing at capacity rate of 90 short tons per day (29,700 short tons per year). During the first nine

months of 1958 the company produced 22,500 tons of high purity brimstone.

Steelman—Saskatchewan : Steelman Gas Company completed their $16 million plant in the winter of 1958 and will remove sulphur at



Shell Oil Co. General view of sulphur recovery plant at Jumping Pound. Vat in foreground.

the capacity rate of 10 short tons per day (3,300 short tons per year), which will be sold to local pulp and paper mills.

The cities of Weyburn and Estevan will join the natural gas system this year and their fuel requirements are to be met by the Steelman plant.

PRODUCTION OF SULPHUR IN ALL FORMS

The production of all forms of sulphur in Canada has expanded over the last eight years from 152,000 short tons in 1950 to over 900,000 short tons in 1957, an increase of 600%.

It is estimated that the smelter gas figure will again be higher in 1958, due to the addition by Canadian Industries Limited of another plant at Copper Cliff, Ontario, which came on stream in March. In addition, Texas Gulf Sulphur Company are conducting pilot plant trials, which are nearing completion, on the economics of a suitable reducing agent to be used in the recovery of sulphur from SO_2 in nickel smelter exit gases at Copper Cliff, Ontario. International Nickel Company at Port Colborne, is applying a process for the recovery of nickel by the direct electrolysis of nickel matte, thus producing 100 t.p.d. brimstone. The only other company actively concerned in sulphur recovery is Laurentide Chemicals and Sulphur Limited, at Montreal, who, with an annual capacity of 30,000 tons, produce liquid elemental sulphur from H_2S collected from the five oil refineries in the Montreal area. This output is consumed by the Canadian Paper Company, Ontario, Canadian Titanium Pigments Limited, Quebec, and the Canadian Industries Limited, alsa of Quebec.

Details of production for the last three years are as follows :--

	1957	*1956*	*1955*
Smelter Gas ...	246,337	236,088	224,457
Pyrite and Pyrrhotite Shipped ...	570,219	473,605	403,986
Recovered sulphur from natural gas	102,171	33,464	25,976
Total* ...	918,727	743,157	654,419

* Official Statistics. These record under pyrites sulphur production by the Noranda process—2,400 tons in 1957—and exclude sulphur recovered at oil refineries.

In recent years improved processes in which by-product pyrites is used as a raw material have been developed in Canada. Noranda Mines Limited, at Port Robinson, Ontario, use pyrites to produce elemental sulphur, sulphur dioxide gas and iron sinter, and at Cutler, Ontario, pyrites and pyrrhotite are used to produce sulphur dioxide for the manufacture of H_2SO_4 and iron sinter. Pyrite and pyrrhotite shipments are expanding as designed consumption capacity is attained at the Noranda acid plant at Cutler.

The growth of recovered sulphur from natural gas has already been discussed and, bearing this increased production in mind, it is likely that the overall production of sulphur in all forms will be approximately 1 million short tons in 1958.

Elemental Sulphur Consumption

The consumption of sulphur in 1957 is estimated to be approximately the same as that for 1956 due to a slight recession in the pulp and paper industry, counterbalanced by a rise in the consumption of heavy chemicals.

Details of consumption of elemental sulphur were as follows:—

	*1957**	*1956*	*1955*
Pulp and Paper	300,000	313,851	300,899
Heavy Chemicals	120,000	108,300	82,947
Rubber	3,000	2,905	2,783
Miscellaneous ...	7,000	6,544	7,619
Total ...	430,000	431,600	393,148

* Estimated

Conclusion

Canada is to-day the second largest consuming country of elemental sulphur in the world, surpassed only by the U.S.A. It now appears that within five years she will also be the second largest producer of sulphur. This achievement will be governed by the speed of development of natural gas sales to Canadian domestic and export markets. The level of gas exports to the U.S.A. may be said to be decisive in shaping the immediate future of Canada's gas industry and thereby its scope as a source of sulphur supply. Although the Borden Report contains a number of restrictive recommendations whereby exports of gas might be curbed on account of the inability of gas producers to market by-products, it is unlikely that the Government would adopt a course of legislative action which might seriously impair the early development of a major national asset. With particular reference to recovered sulphur, the approach to the problem of disposing of the large and mounting volume of this by-product at once affects the producers, but probably has more far-reaching implications for the world sulphur industry as a whole. If there are no ready sulphur outlets, gas producers can either cease exploiting sour gas wells, thus avoiding the production of sulphur, or, as seems necessary for efficient operation, draw on sour gas reserves and stockpile that part of the sulphur output for which there is "no practicable market." The alternative of disposing of this part of the output at any price must be viewed in the light of the absolute cost of transportation from recovery plant to consumer and of the adverse effect which, in the competitive state of the gas industry, this added unrequited charge of sulphur extraction and recovery would impose on the economics of gas supply. It is evident that for at least five years the sulphur demand within an economic radius—at present about 800 miles—of sulphur production centres of West Canada, is limited to perhaps one-quarter million tons annually. Canada's major brimstone consumers, the pulp industry of Quebec and Ontario, are 2,000 miles distant and at present purchase imported U.S. bright sulphur at about $33 per long ton c. & f. Montreal. Also consumers in the North Central United States, notably in Illinois, enjoy similarly priced supplies. Less acute but no different in principle is the movement of sulphur to Canada's potential overseas markets, as it can be assumed that shipments from Vancouver to the Far East and to Australasia may be priced on a similar f.o.b. basis as U.S. and Mexican material and remain competitive. The problem to be reconciled is that a growing sulphur surplus arises at a great distance from major consuming centres; the solution appears to entail either a seriously uneconomic approach to the pricing of sulphur or to its transportation or both. It is confidently expected by many sections of the industry in Canada that the railway companies will agree to establish special sulphur tariffs in view of the accepted principle of favoured commodity rates in the Canadian railway tariff structure. With regard to supplying the markets in Eastern Canada an important factor is that at present the Eastbound volume of rail traffic is substantially lower than that moving to the West. Another factor which could lower transport costs is the mounting volume of Lake shipping, which will further diversify when the St. Lawrence Seaway is opened this Spring.

Canada's sulphur marketing problem is one which in varying degrees has to be faced by all producers of recovered sulphur and which by virtue of the growing importance of this branch of the sulphur industry will make an increasing impact and therefore requires early solution. It is evident that once the level of sulphur production entails shipments to consumers outside the narrow radius, which at present is supplied at about $23.50-$25 f.o.r. recovery plant, the question of differential pricing will have arisen, a feature which hitherto has been strenuously resisted by all sections of the sulphur industry.

Prices and Trends

THE PAST THREE MONTHS showed, as expected, practically no change in the world sulphur supply position. The price picture during this period nevertheless deteriorated. Brimstone prices although officially unchanged, were unstable and on a weakening trend as the result of offers notably to consumers in the more competitive markets, on c & f and delivered terms which incorporated disguised discounts. The decision on the part of European pyrites producers to reduce their prices with effect from the New Year had been expected, but the extent of the reduction—10s. per metric ton, equal to about 15/—indicates a firm determination to safeguard their position in the face of increasing pressure from brimstone suppliers. The mainspring governing the marketing policies of the competing producers of brimstone as well as the conflicting interests of the sellers of brimstone and pyrites, is the impact on the world sulphur markets from 1960 onwards of recovered sulphur from Lacq. None of the many other factors contributing to current competition or to future statistical weakness of sulphur markets have caught the imagination of the industry in the same way despite the probability of their more far reaching effects.

Grave concern is justifiably expressed by several leaders of the U.S. Frasch sulphur industry. Mr. F. E. Lewis, vice-president of the Jefferson Lake Sulphur Company, in an address at the end of October to the Canadian Institute of Mining and Metallurgy at Calgary, emphatically called for a speedy return to a brimstone price of $30 or more and condemned the prevailing practice of price reductions and "Off the record" quotations. In common with views expressed earlier in the year by Mr. Langbourne M. Williams, Chairman of the Freeport Sulphur Company, he foresaw a rapid expansion of world demand to 24 million tons by 1967 and while underlining the need for stability in the interest of consumer confidence wanted the industry to follow a concerted policy of conservation of reserves. This in his view could only be achieved if higher prices restored to the industry the incentive for new development whilst failure to do so could precipitate another supply crisis.

The discrepancy between views like those expressed by Mr. Lewis and the present picture of the world markets can be found in the divergence between the inferred possibility of a long term shortage and the now evident statistical picture of short and medium term oversupply. In respect of the distant future no conclusive arguments have yet been marshalled for or against, but a comparative study—now in preparation—of the pressure of rising demand and the concurrent rate of growth of the sources of supply which are throwing the short term sulphur market out of balance should provide the necessary pointer. It is becoming increasingly evident that during the period of oversupply, which is to a large extent determined by the growth of recovered and by-product sulphur in various forms, the established practice of uniform prices is under pressure and that a system of differential pricing, in terms of the net ex-mine return to the producer, is emerging. Whereas a rigid agreement between producer interests might result in a temporary demarcation of spheres of marketing interest it is illegal in the United States and probably also impractical. During the next twelve months the actual supply picture is not likely to become seriously unbalanced and a re-adjustment of marketing policies and production plans may be politic. Following Mr. Lewis's line of thought the need of the U.S. Frasch sulphur industry of a higher and more remunerative price is not irreconcilable with the oversupply of sulphur caused by by-product materials. It does, however, require the acceptance of the latter being subject to differential pricing and also of the temporary—even in terms of five to ten years—halt to aggressive selling promoted by price cutting on the part of primary producers who at present supply more than one-half of world sulphur requirements.

PRICES

Brimstone

U.S. Frasch sulphur prices in domestic and export markets remain posted at $25 per long ton f.o.b./f.a.s. U.S. Gulf ports for bright material. A discount of $1 per ton for off-colour is similarly posted by all producers selling this grade and for shipments ex-mine the

differential remains $1.50 per ton below the respective f.o.b./f.a.s. prices for bright and off-colour sulphur. Intent on securing the desired volume of business in the more competitive markets, U.S. producers are quoting increasingly on the basis of delivered terms incorporating disguised discounts as such or at times these derive from exceptionally favourable freight costs. This applies equally to The Sulphur Export Corporation selling on behalf of all U.S. producers in export markets as to individual producers competing in the domestic market. The most severe competition is met in Europe from Mexican and French sulphur supplies and along the Eastern Seaboard from Mexican imports and domestic recovered brimstone. Current quotations indicate delivered price of $25-28 per ton along the U.S. Eastern Seaboard, $26-27 per ton at North-Western European ports and $31 in South Africa and Eastern Canada.

Mexican Frasch sulphur exports continue to be based on $23.50 per ton f.o.b. Coatzacoalcos for fully filtered yellow material. Off-colour and unfiltered material is sold at prices ranging down to $20.50 per ton f.o.b. Compared with the cost of shipping in tariff bound U.S. vessels, the lower freight charges for other flags shows a substantial saving of up to $2-$2.50 per ton and Mexican exports to U.S.A. benefit accordingly. This feature is aided by the continued weak state of the freight market which allows the replenishment of Pan American Sulphur Company's stockpile at Tampa and Norfolk under very favourable terms.

Prices paid by the Ente Zolfi Italiani to Italian producers for the year 1958/9 have been assessed as follows:—

Quality	*per metric ton*
Gialli Extra ... ... Min: 99.5%	L.30,000
Gialli Comuni ... ... Min: 98%	L.29,000
Bruni Tipo Marche Romagna Min: 99.5%	L.29,000
Bruni di prima scelta ... ... Min: 98%	L.28,000
Bruni di seconda scelta ... Min: 96%	L.27,200
Dry sulphur concentrates ... Min: 85%—Max: 3% H_2O	L.25,000
Wet sulphur concentrates ... Max: 15% H_2O	L.18,000

Export prices of Gialli Comuni are reported to be based on L. 23,000 per metric ton f.o.b. (£13 7s. per ton) and in Mediterranean markets exceed the cost of competing supplies by at least Lire 5,000 per metric ton (£3). As the volume of exports declines an increasing proportion of subsidies is devoted to promoting greater mining efficiency and modernisation.

In Australia the pool price of imported brimstone was reduced on 1st July, 1958, by £A2 5s. to £A17 10s. Further offers of Chinese sulphur are reported at about £10 per ton f.o.b. Tientsin In Japan a further reduction of about Yen 2,000 in the domestic price took place in October. This has now declined to Yen 19,000-20,000 per metric ton f.o.r. mine.

Societé Nationale des Pétroles d'Aquitaine selling sulphur recovered at the Lacq gas field is implementing the policy of obtaining the highest possible price compatible with securing the desired share of a market. Prices quoted are comparable with the delivered cost of imported supplies from U.S.A. and Mexico. Following the currency reforms the actual quotations are under reconsideration.

In Western European countries the price of recovered sulphur has in general not changed although in some instances selling pressure by importers of U.S. and Mexican and French on individual customers has caused price shading.

In West Germany the domestic price of brimstone recovered from spent oxide by Ruhrgas A.G. and from oil refinery gases is reported to be in the range of D.M. 118-125. In Belgium and Holland the price of domestic recovered sulphur is reported at BFrs. 1,500 and DFl. 110 respectively. In Scandinavia the demand by the pulp industry has remained unchanged and as the result of steady offerings of U.S., French and Mexican sulphur the sulphur market remains weak. In Sweden supplies of brimstone recovered from oil shales by Svenska Skifferolje A.B. are quoted Skr. 180-200 although imported material reaches Swedish ports at Skr. 160-165. Prices of brimstone recovered by Orkla Metal A/S from smelting cupreous pyrites too were reduced in the company's main markets by 10-12% during the second half year to NKr. 220-230.

In Western Canada prices to domestic users, pulp mills and acid makers, is $23-$25 per ton f.o.r. recovery plant which at remote locations results in a cost to the consumer of as much as $45 per ton. Export quotations are reported at $23.50 f.o.b. Vancouver. In Eastern

Canada recovered sulphur is quoted competitively with imported U.S. brimstone which is reported to be landing at $31-$33.

The following table indicates broadly the delivered cost of brimstone of varying origin at principal consumers' destinations based on posted prices and ruling freight rates. The rates shown are either actual charters made at the end of September or reliable indications:—

f.o.b. Country of origin	*U.K.*		*N.W. Europe*		*France (Mediterranean)*		*India*		*Australia*	
U.S.A. $24-25 ...	(45s.)	£10¼-11½	(37s. 6d.)	£10½-10⅞	(45s.)	£10¼-11½	(80s.)	£12½-12⅞	(65s.)	£11¼-12½
Mexico $20.50-24	(45s.)	£9½-10¼	(37s.6d).)	£9⅝-10½	(45s.)	£9½-10¼	(80s.)	£11¼-12½	(65s.)	£10½-11¼
Italy Lire 23,000*	(30s.)	£14⅜	(25s.)	£14⅝	(22s.)	£14½	(50s.)	£15⅜	—	—
Canada $23-50 ...	(60s)	£11⅝	(55s.)	£11⅝	(55s.)	£11⅝	(70s.)	£11⅝	(60s.)	£11⅛

Freight indications ( ) have been reduced to f.i.o. terms to provide a common basis for comparison. *Per metric ton.

Pyrites

In view of increasing pressure on their established outlets, European pyrites producers decided to reduce their prices by 10 shillings as from January 1st, 1959. Thus the price of Spanish crude pyrites, notably Rio Tinto and Tharsis Sulphur and Copper, during the first half of 1959 is 67s. 6d. per metric ton f.o.b. Huelva basis 48% sulphur and Rio Tinto flotation concentrates are shipped at 57s. 6d. Corresponding reductions have been made by Cypriot producers and also by Portuguese producers, the latter having reduced the price of their pyrites to 62s. 6d. per metric ton f.o.b. basis 48%S. Other concessions reported to have been made by Spanish producers include a better charter party and credit terms.

It is widely held that the extent of the price reduction must be viewed in conjunction with the anticipated further reduction of residues values in all markets notably in Germany. Here the prices of purple ore, which is one of the criteria in setting the pyrite residues price, is expected to decline by about 15%.

Domestic prices in Spain, Portugal and Italy, the principal indigenous pyrite markets, are being reviewed by the Authorities. Upward adjustments in Spain and Portugal and a price reduction in Italy with a view to aligning dependent chemical and fertilizer prices with European market conditions are expected to be authorised in the near future.

Another feature which could affect European pyrites prices is the re-emergence of differential exchange rates in Spain, mainly on account of the strong inflationary pressure. The possibility that rising costs may oblige producers to appeal to the Government for this aid in their competitive struggle cannot be excluded.

Freights

The voyage index of the U.K. Chamber of Shipping (1952=100) which in September stood at 65.7 advanced to 74.6 at the end of December. Under the influence of grain chartering the market advanced for a short period without, however, affecting the volume of laid-up tonnages of about 6.3 million DWT. As there has been little improvement in the reduced level of movement of basic commodities the weakness of the freight market reasserted itself. From the United States and Mexican sulphur ports in the Gulf of Mexico spot vessels to the United Kingdom are reported at about 49s. and to the continent at $5.60 for liberty vessels.

European pyrites freights have remained constant from Huelva to Antwerp/Rotterdam/Hamburg vessels of 8,000 tons were chartered at 22s. 6d. whereas from Cyprus 25s. to 28s. was secured. From Huelva to the U.K., where most of the trade is carried in the smaller-sized vessels of 3,000-5,000 tons which are in greater demand, rates ranged from 29s. to 36s. and from Cyprus to the U.K. a 9,500-ton vessel was fixed for 38s.

Rates for Lacq recovered sulphur from Bayonne are quoted at 16s. to 18s. to continental ports and 24s. to 26s. to United Kingdom.

Present rates to the Far East are subject to considerable fluctuations. India (East Coast) from the U.S. Gulf was quoted at 80s. U.S. Gulf to New Zealand was fixed at 77s. 6d. A vessel of 9,500 tons from U.S. Gulf to Brazil was favourably chartered at 35s. 8d.

SUPPLY

Brimstone

In the United States domestic demand improved as a result of greater industrial activity and in consequence, Frasch sulphur producers have increased production from the exceptionally low monthly average of 330,000 tons in the

third quarter. Recovered sulphur production at oil refineries advanced seasonally and Mexican sulphur imports have increased substantially and adversely affecting domestic Frasch sulphur usage and causing stocks to remain at about 4.7 million tons. Exports are buoyant and little improvement is expected immediately as the result of the removal on 10th November, by the Bureau of Foreign Commerce, of the need for export licences to Western destinations and also the embargo on sulphur shipments to all iron-curtain countries (except China) which now only require export licences. The level of Frasch sulphur production in Mexico remained high and output by the end of 1958 exceeded as anticipated, 1¼ million tons. Pan American Sulphur Company continue to operate at about 60% of installed capacity, but Gulf Sulphur Corporation raised its daily output to over 900 tons. Although domestic sulphur demand has increased to 100,000 tons per annum, recovered sulphur deliveries are also greater so that Frasch sulphur producers have not been able to secure as great an outlet as they hoped. Increased exports shipments, notably to the United States, have allowed the level of stocks to remain at about three-quarter million tons. In Italy production of fused sulphur is about 150,000 tons per annum and, as the result of shrinking exports and static deliveries to the home market, stocks are estimated to have risen to 240,000 tons by the end of the year.

Expansion of brimstone production facilities is reported from several locations in the U.S.S.R. In Poland the great sulphur project at Piaszeczno is reported to be progressing in accordance with plans and for 1960 an output of 30,000 tons elemental sulphur is foreseen.

Recovery

In the United States higher oil refinery activity in the Autumn helped to raise the year's recovered sulphur output to 600,000 tons, the highest on record. Balanced order books ensure the ready disposal of this output to industry.

In Canada now that the terms of the Borden Commissions Report in relation to the Natural Gas Industry are known, plans by the companies concerned in gas export are being clarified. The 1958 level of sulphur recovery is not likely to exceed 150,000 tons but plant facilities having been completed a rapid advance of gas cleaning and supply and consequently sulphur recovery is expected for 1959. Sulphur recovery at Lacq by Societé Nationale des Pétroles d'Aquitaine advanced towards the close of the year to 30,000 tons per month, a rate more than double that of the third quarter when about 40,000 tons was produced. Oil refineries operations in Europe have advanced seasonally and output of recovered sulphur partly as the result of additional plant is estimated to have risen to 14,000-15,000 tons per month.

Vat breaking at Lacq.

Pyrites

The level of European pyrites shipments remained substantially unchanged during the closing months of the year and it is estimated that 1958 shipments may be as much as 10%-12% below those of 1957. Production and shipments from Cyprus and by Portuguese producers are reported to be higher, whereas the 1958 operations in Spain and Norway show adverse results.

In South Africa the level of by-product pyrites output is being increased by 3,500 tons per month following the installation of plant at Harmony Gold Mines. In Japan recession in the fertilizer and textile industries is adversely affecting pyrites output which is expected to be 5% lower than in 1957, when it totalled 3.1 million tons.

UNITED STATES SULPHUR

Frasch Sulphur

Production of Frasch sulphur during the third quarter of 1958 amounted to 1,050,846 tons compared with 1,201,360 tons in the preceding quarter and 1,374,300 tons in the corresponding period of 1957. Total production for the first nine months of 1958 was 3,558,152 tons, about 550,000 tons (13%) less than in the same period of 1957. In each

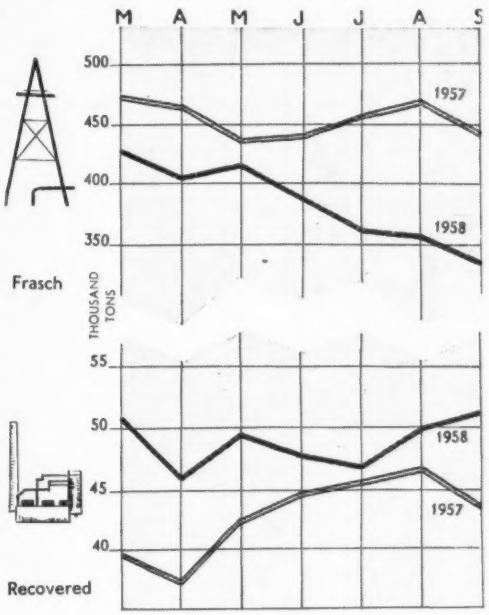


Fig. 4. Monthly production.

successive month of the third quarter production has further receded and in September output—335,823 tons—was the lowest for any one month during the past ten years.

Texas Gulf Sulphur Company who commenced operations at their new Fannett dome in May, are reported to be only working at approximately one-third capacity and producing from this dome between 300-500 tons per day. Production at the company's other domes has been reduced considerably, notably in the case of high cost units. Gross revenue from sulphur sales in the third quarter at $14 million was lower by $1.3 million compared with the corresponding period in 1957, whilst operating expenses had been reduced by almost 50% to $8.8 million. This is believed to be attributable to the closure of high cost producing wells and the curtailment of exploration activities.

On account of the relatively small size of their operations Duval Sulphur and Potash Company and Jefferson Lake Sulphur Company aim to maintain their normal production rate as any reduction would adversely influence the economics of production. Duval Sulphur and Potash Company is expected to produce approximately 170,000 tons in 1958 at their Orchard dome, and Jefferson Lake Sulphur may be expected to produce about 400,000 tons from their Frasch operations.

Apparent sales of Frasch sulphur in the third quarter amounted to 1,137,660 tons as compared with 1,371,878 tons in the same period in 1957, a decrease of 17%. During the nine months of 1958 3,463,997 tons were sold, which shows a decrease on the corresponding nine-monthly period in 1957 of 372,883 tons or 9¾%.

Stocks fluctuated during the quarter by up to 100,000 tons mainly on account of seasonal demand and at the end of September stood at the high level of 4,634,353 tons.

Recovered Sulphur

The production of 149,814 tons of recovered sulphur in the third quarter of 1958 showed an increase of 13,886 tons or 10¼% compared with the same period of 1957.

Installed sulphur recovery capacity continues increasing. The Anlin Company will complete in mid-1959 a $2 million sulphur recovery plant adjacent to Shell Oil Company's Wood River, Illinois, refinery, where it will recover 150 long tons of sulphur per day from sour refinery gas supplied by Shell. Anlin already operate a similar 35 tons per day recovery plant at California Oil Company's Perth Amboy, N.J. refinery.

Other sulphur recovery plants recently brought on stream are those of Magnolia Petroleum and Olin Mathieson Chemical Corporation, both at Beaumont, Texas, and each with a capacity to recover 70 tons of sulphur per day from oil refinery gases.

Demand for recovered sulphur remained firm during the quarter and apparent sales

totalled 138,241 tons, whilst stocks at the end of September were 172,446 tons, an increase of 12,000 tons. During the first nine months of 1958 consumption was nearly 25% greater than in a similar period of 1957.

Sulphuric Acid

During the third quarter of 1958, production of sulphuric acid was 3.69 million short tons as compared with 3.94 million short tons in the corresponding period in 1957, a reduction of 6½%.

The price of sulphuric acid at $22.35 has now remained stable since 1953, and although last year sulphur prices were reduced, this has not affected the price of sulphuric acid. A feature of the market has been the keen competition on the eastern seaboard where there have been price discounts of up to $1 per ton in New England and between $2-$4 per ton in the New Jersey-New York area.

The low level demand for sulphuric acid on the part of the steel industry began to improve in September. The rayon industry's needs remained at a low level throughout the quarter, but at the end of September there were positive signs of improvement. One of the few stable points of the markets has been the maintenance of demand from the oil industry notably for alkylation purposes. Expansion of sulphuric acid capacity is being maintained, significantly by-product sources of sulphur are playing an increasing part in the new projects. At Hammond, Indiana, Stauffer Chemical Company has just brought on stream a new sludge acid regeneration plant. It is designed to process 450 long tons per day from the sludge acid bought from petroleum refiners in the Chicago area.

Allied Chemical Company installed a new sulphuric acid plant at Anacortes, Washington. With a daily capacity of 300 tons of sulphuric acid, the plant derives its sulphur supply from H_2S and sludge acid supplied by the nearby Shell Oil refinery.

Dixon Chemical Incorporated is seeking finance for the construction of a 300,000 tons per year sulphuric acid plant at Paulsborough, New Jersey; Chemical Construction Corporation will build the plant which is due on stream in September 1959. In November the company filed a registration statement with the Securities and Exchange Commission seeking registration of $5.9 million of 6% subordinated debentures due 1st December 1978 and 236,000 shares of its $1 per common stock. The plant will be designed primarily to serve oil refineries in the Delaware Valley area. The company has undertaken this expansion because of the lack of home produced sulphuric acid in this area where the annual consumption is 650,000 tons per year and local production only 250,000 tons.

Non-acid Uses

Demand from the industries consuming sulphur for purposes other than sulphuric acid manufacture appears to have receded more than acid sulphur requirements. The setback of the rayon industry has been accentuated by the relatively low level of operations in pulp and paper manufacture. After several years of working at or in excess of rated capacity, the industry now accepts, as normal, an 80-85% employment of plant. No new major projects appear to be envisaged.

The American Viscose Corporation is to halt rayon production at Raonoke, Virginia, where its 35 million lbs. per year unit has been operating at only 60% capacity. However, the company has four other rayon plants including Lewistown, Pennsylvania, and Parkersburg, West Virginia, where continuous filament is made, and therefore it is anticipated that the staple fibre and tyre yarn output will not be affected. In conjunction with this action on the part of the American Viscose Corporation, Stauffer Chemical Company closed down in July their carbon disulphide plant at Raonoke.

E.I. du Pont de Nemours Inc. have estimated that the nylon share of the replacement tyre business has been growing during 1958 and that nearly 50% of the replacement tyres being sold are equipped with nylon cord. This represents a 17% increase on 1957 and 30% increase on 1956 consumption. It is expected that the use of nylon will encroach further upon the rayon market in 1959.

Trade

United States imports of sulphur from Mexico have increased by one-third to approximately 160,000 long tons in the third quarter of 1958. This has been mainly the result of the stepping up of exports by Pan American Sulphur Company who, in the third quarter, exported approximately 130,000 tons to the United States, an increase of 60% over the corresponding period in 1957.

Exports of crude sulphur at 374,318 tons showed an increase of 4% over the corresponding quarter of 1957, and for the nine-monthly period an increase of 3¼%. The increase may be attributed to doubled exports to Australia, whither, from January to September 1958 102,422 tons were shipped as were also greater shipments to the United Kingdom (22,000 tons), India (12,000 tons) and Switzerland (11,000 tons). Major reductions occurred in the deliveries to France (16,000 tons lower) and Canada (40,000 tons), which in both countries were to the impact of indigenous recovered sulphur.

Summary

Despite strong competition, the United States sulphur suppliers selling jointly through the Sulphur Export Corporation expanded their markets during the third quarter and laid the foundation for a satisfactory end year position. Seasonal factors in sulphur consumption weakened the effect of the general improvement evident in the United States economy in the late summer months. This coupled with a 60% increase in imports from Mexico and rising recovered sulphur usage, kept down domestic Frasch sulphur consumption and in response to this trend production was curtailed to a level lower than at any time in the past ten years. This appraisal of the level of Frasch sulphur operations—substantially below available capacity even before the entry of new domes now under construction—is likely to become a necessary feature of the industry for several years to come, especially during the expansion period of the major producers of recovered sulphur, i.e. France, Canada and the world wide petroleum refining industry.

Whereas the industry's position is vulnerable in her export markets, her ability to maintain supplies to a large sector of the United States domestic market should ensure that in the foreseeable future United States Frasch sulphur supplies will account for a major proportion of world brimstone deliveries.

Review of U.S. Sulphur in 1958

THE ANNUAL SURVEY of the U.S. Sulphur Industry traditionally given by the President of the Freeport Sulphur Company, was this year delivered by Mr. C. A. Wight who took up his new appointment in October 1958. Mr. Wight, a former head of the London Office of the Bankers Trust Company, and a graduate of Yale University, has been with the Freeport organisation since 1948, holding in addition a number of directorships with companies in the U.S.A. Mr. Wight succeeds Mr. Langbourne M. Williams, who will continue to be Chairman and Chief Executive Officer. Mr. P. E. Neaman, who succeeds Mr. Wight as Chairman of the Executive Committee is a distinguished lawyer and has been associated with the Freeport organisation since 1930, during which time he has held numerous important posts.

"An increase in U.S. consumption toward the end of the year, Mr. Wight said, was insufficient to bring the annual rate to that achieved in 1957. Shipments abroad however reached an estimated 1,575,000 tons, which is slightly higher than in 1957 and only 75,000 tons below the record shipped in 1956.

Preliminary data indicates that total domestic consumption of sulphur was fractionally less than 1957, reflecting the lower output of such major consuming industries as paper, steel, petroleum refining, rubber and textiles. On the other hand, the relatively good year experienced by the fertilizer industry and segments of the chemicals industry, two of the largest consumers of sulphur, helped to bolster the consumption figure.

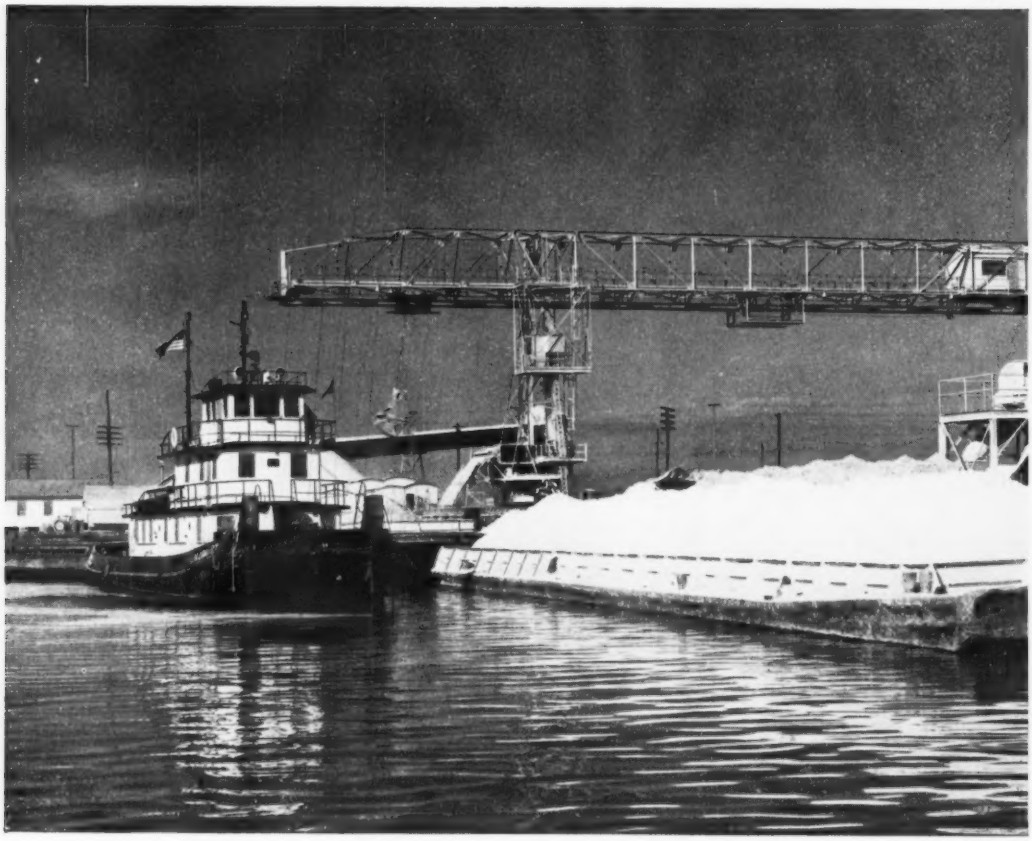
Sulphur production was also down, for total output from all sources in the U.S. amounted to an estimated 6,200,000 long tons, compared with 7,000,000 tons in 1957. The drop in production was the result not only of lower consumption but also of increased imports and, more significantly a cutback in stockpiling. Of the total production, three quarters was brimstone mined by the Frasch hot-water process from salt dome deposits located along the coast of the Gulf in Louisiana and Texas. Indicated Frasch production was approximately 4,650,000 tons, compared with 5,490,000 tons in 1957. Of the balance of the output 630,000 tons represented elemental sulphur recovered from refinery gases and sour natural gas; 400,000 tons sulphur contained in pyrites; and 520,000 tons sulphur in various forms from other sources. Imports were at a record of approximately 760,000 tons, compared with 669,000 tons in 1957. The bulk—an estimated 600,000 tons—was Frasch sulphur produced from Mines in Mexico."

Twelve Frasch-process mines were in operation in the U.S. in 1958, including a new mine opened in May by Texas Gulf Sulphur Company at Fannett, Texas. Texas Gulf remained the largest producer, followed by Freeport Sulphur Company, Jefferson Lake Sulphur Company, and Duval Sulphur and Potash Company.

To meet more effectively the increased competition abroad from foreign sources of sulphur the four U.S. Frasch producers during the year formed the Sulphur Export Corporation to sell their sulphur outside the North American continent. The jointly owned company was created under the terms of the Webb-Pomerene Act, which permits companies within an industry to form a single organisation to transact their business abroad.

The quoted price of sulphur in the U.S. has remained unchanged since the reduction of $3 a ton effected late in 1957. Prices during 1958 were quoted at $25 per long ton f.o.b. port and $23.50 f.o.b. mine.

Two new U.S. salt dome deposits were under development, both projects of Freeport Sulphur. The largest is Grand Isle, a discovery of major magnitude located off the Louisiana coast in 50 feet of water seven miles from the nearest land. The second, known as Lake Pelto, is situated some miles away in the shallow, partially protected water along the coast. At Grand Isle, a steel structure measuring nearly a mile in length was nearing completion at year's end, and production is expected in 1960.



Freeport Sulphur Company. Loading barges at Port Sulphur.

SULPHUR IN MEXICO

DURING A PERIOD when competition in the world sulphur market is becoming keener, partly as the result of the rising volume of sulphur supplies and partly due to the reduced level of industrial activity, particularly in Europe and the U.S.A., the Mexican sulphur industry has maintained a high level of activity in production and sales. In the third quarter of 1958 production amounted to 313,755 tons and, although slightly lower than the previous quarter's output of 315,421 tons, it was nearly 69,000 tons (28%) higher than in the third quarter of 1957. Of this total, approximately 291,000 tons was accounted for by the three established Frasch sulphur companies—Mexican subsidiaries of the Gulf Sulphur Corporation, the Pan American Sulphur Company and the Texas Gulf Sulphur Company—a fourth Frasch sulphur producer, Texas International Sulphur Company plans to exploit the Texistipec dome. Petroleos Mexicanos sulphur production from its recovery installations and the surface mines at San Luis Potosi produced a total of approximately 24,000 tons wholly absorbed by the domestic market, which is now running at a rate slightly in excess of 100,000 tons per annum.

Shipments in the period July to September 1958, totalled 305,567 tons, still supplied entirely by the Pan American and Gulf Sulphur companies, compared with 234,441 tons in the previous quarter and 232,974 tons in the corresponding quarter of 1957. But for the fact that bad weather in the Gulf of Mexico affected shipping in September, shipments would have been greater. During the first nine months of 1958 shipments amounted to 784,691 tons, equivalent to an annual rate of 1,046,000 tons, compared with 631,707 tons and 842,000 tons respectively achieved in 1957.

At the end of September, stocks of the two exporting companies were 25,000 tons greater than on 1st January. In the case of Pan American the low rate of stock accumulation is due to production having been kept in step with sales, whilst Gulf Sulphur has not yet achieved a sufficient level of production to permit much stock building at the present high

Gulf Sulphur Corp. New movable crusher showing movable conveyor on left and stationery conveyor belt on right. All equipment has a standard capacity of 500 tons per hour.

rate of shipments. At this rate Gulf Sulphur's stocks, now estimated at 51,000 tons, represent about ten weeks' supply.

Pan American Sulphur Company

Shipments of sulphur to the end of September are running considerably ahead of forecasts made at the beginning of the year by Mr. Harry C. Webb, the company's president. At that time it was believed they would remain at the previous year's level of 690,000 tons or slightly in excess, whereas by September they had already reached 588,000 tons. Shipments in the third quarter were 232,000 tons compared with 181,000 tons in the second quarter and with 192,000 tons in the corresponding quarter of 1957. Production of 194,499 tons was slightly lower than the previous quarter's 209,182 tons, this reduction being in line with Pan American's policy of controlling inventory accumulation. The third quarter's figures brought production for the first nine months of 1958 to 612,000 tons, very close to the planned annual rate of 800,000 tons.

The high level of activity maintained in the third quarter is reflected in the company's results for the period. Net earnings amounted to $1,038,505 as compared with $922,934 in the corresponding period of 1957, bringing net earnings during the first nine months of 1958 to $2,597,138—$2,560,626 in January-September 1957—despite the lower price of sulphur. It is also interesting to note that increased sales over 1957 have been achieved with lower selling costs. The company's ability to supply almost entirely filtered yellow sulphur and to supply its largest market, the Eastern United States, from strategically based stocks, together with the backing of a sound world-wide sales network which is allied to that of International Ore and Fertilizer Corporation of New York, have been significant elements in maintaining this strong position.

Gulf Sulphur Corporation

Production during the third quarter of 75,936 tons was the highest in the company's history and compares with 66,388 tons in the previous quarter and 54,719 tons in the first quarter of 1958. The installation of additional water heating capacity has considerably assisted production and the present policy is to consolidate this position, particularly by building stocks beyond their present level of 51,000 tons which represent ten weeks' supply. In order to achieve this the present rate of production would have to be raised by at least 50,000 tons per annum to an average of 1,000 tons per day. At that level of output and sales the company may be expected to be operating profitably. Shipments for the third quarter of 73,000 tons were also the highest on record compared with 55,000 tons in the previous quarter and 61,500 tons in the first quarter. Total shipments for the first nine months of 190,000 tons represent an annual rate of 253,000 tons, which compares with the annual rate of production of 263,000 tons.

Gulf Sulphur Corp. Vat breaking. New power shovel on left equipped with three yard bucket. Discharge directly into portable crusher.

Texas Gulf Sulphur Company

Cia. Exploradora del Istmo, the Mexican subsidiary of Texas Gulf Sulphur Company continues to stockpile the output which is currently estimated at an annual rate of approximately 100,000 tons. The stockpile, stored solid in vats near the mine site, is estimated to amount to 150,000-170,000 tons.

Texas International Sulphur Company

It is reported that the company has completed the Frasch sulphur production facilities at the Texistipec dome but steaming has not begun as no wells have yet been connected. It is believed that the plant is rated at 250 tons per day and it is unlikely that at the start of operations rated output would be achieved. The plant, a mobile installation formerly owned by Standard Sulphur Company, was moved from Damon Mound, Texas, and re-erected by Mr. Gilbert Ebarb.

Negotiations between Texas International and Duval Sulphur & Potash Company, who

SULPHUR PRODUCTION

		Pan American Sulphur Co.	*Gulf Sulphur Corporation*	*PEMEX and Texas Gulf Sulphur*	*Negociacion Minera de Azufre SA*	*Total*
1958	January	70,627	18,940	22,800	1,200	113,567
	February	64,182	14,056	13,000	1,500	92,738
	March	73,743	21,945	10,721	1,500	107,909
	April	70,235	20,800	11,500	1,500	104,035
	May	78,221	18,983	11,777	1,575	110,556
	June	60,726	26,605	11,999	1,500	100,830
	July	54,843	27,664	12,500	1,500	96,507
	August	71,943	24,790	12,075	1,450	110,258
	September	67,943	23,482	14,695	1,100	106,990
	October	70,984	21,532	14,800	1,360	108,576
	November	72,981	23,316	15,000	1,400	112,697

have also been examining other Mexican properties, on the possible acquisition by the latter company of Texas International's concessions, have now been broken off without anything positive having been achieved.

Petroleos Mexicanos

It is reported that additional plant and increased gas throughput have raised the company's recovered sulphur production in the third quarter to between 5,000 and 6,000 tons per month. In 1958 production is expected to total 60,000-70,000 tons and meet about four-fifths of domestic sulphur needs.

Conclusion

The Mexican sulphur industry is entering a critical phase in its development and, despite the disparity of size, scale of operations and activity of individual Mexican Frasch sulphur companies, they individually and collectively are faced with common problems which result from growing competition in the world sulphur markets and which call for unity of purpose. Some existing outlets in Europe and the Middle East will undoubtedly be lost to Mexico and much will depend on producers' ability to replace these. The position of the U.S.A. as the largest market has recently been further enhanced and it is likely to assume even greater importance in the future. Although the South American countries offer a great potential market for sulphur, the Mexican producers are severely handicapped by the absence of regular shipping services to South American ports, whereas the United States producers are adequately served in this way.

The lead in respect of future policy will be originated by the Pan American Sulphur Company whose status as a major world producer has endowed it with a position of strength, from which the management could aim unilaterally for further expansion or apply its influence in returning a measure of stability to world markets.

Gulf Sulphur Corporation is now probably operating at the break even level and it could establish itself as a profitable small producer if output were raised to average 1,000 tons per day and stocks were increased. Its dependence on the goodwill of the larger producers cannot fail to colour its policy.

The domestic market is expanding rapidly and at the present level of 100,000 tons it exceeds the output of Petroleos Mexicanos and Negociacion Minera de Azufre. The provision of the balance however small, is an attraction to the Frasch sulphur sector of the industry. Cia. Exploradora del Istmo who have so far refrained from delivering to export, may well find the pursuit of the domestic market attractive and politic. The bulk of domestic sulphur consumption is located in the fast growing fertilizer industry but this is at present tending to develop principally in those sections which manufacture fertilizers not based on sulphur. Growth of other sulphur consuming industries therefore, assumes greater importance. Although the future pattern of consumption is uncertain as the Mexican Government is intent on development of the chemical industry being balanced and to some extent controlled by its investment policy, sulphur usage in the early 1960's will probably reach 200,000 tons. There is no doubt that any increase in the output of recovered sulphur derived from the anticipated growth of natural gas and oil refinery output, will receive priority in the domestic market over Frasch sulphur supplies. Consequently the Mexican Frasch sulphur industry lacking the umbrella of a substantial and secure home outlet must depend in the first place on its ability to adjust itself to the changing market pattern in the United States as well as in other export markets.

DARK SULPHUR PURIFICATION AT JALTIPAN DOME

THE FRASCH SULPHUR operations of the Pan American Sulphur Company, now the third largest brimstone producer in the world, are based on the extensive dome deposit of Jaltipan on the Isthmus of Tehuantepec in Mexico. The sulphur formation of the dome consists of crystal deposition in limestone and gypsum with tar-stained horizons. In the course of Frasch operation contact between hydrocarbons and the molten sulphur gives rise to the formation of complex organic sulphides. These impart dark colour to otherwise yellow sulphur, the extent of the contamination being dependent on temperatures in the underground system and the time of contact between the sulphur and other contaminant.

The company management's decision to purify the contaminated output was followed by the installation of plant; also it resulted in both the adaptation of known purification techniques to the special conditions of Jaltipan as well as the development of new process steps. The following is an authentic account of the cleansing operations.

(a) Activated Clay Treatment

The treatment of contaminated sulphur by activated clay is based on the preferential adsorption of hydrocarbons and colouring matter from a sulphur solution. For any particular batch of crude sulphur the adsorption of hydrocarbon contaminant follows an isotherm, which is a composite of the adsorptive behaviour of all of the hydrocarbons and organic sulphides in the sulphur after the crude is first ridded of undissolved hydrocarbon by filtration.

In most crude sulphur, the quantity of dissolved petroleum rarely exceeds 0.4% carbon, although the total quantity of petroleum contaminant, including the dispersed, may amount to as much as 1.5%. Of the maximum amount of 0.4% dissolved hydrocarbon, about 85% is composed of hydrocarbon sulphides or unsaturates which are quite readily absorbed on activated clay.

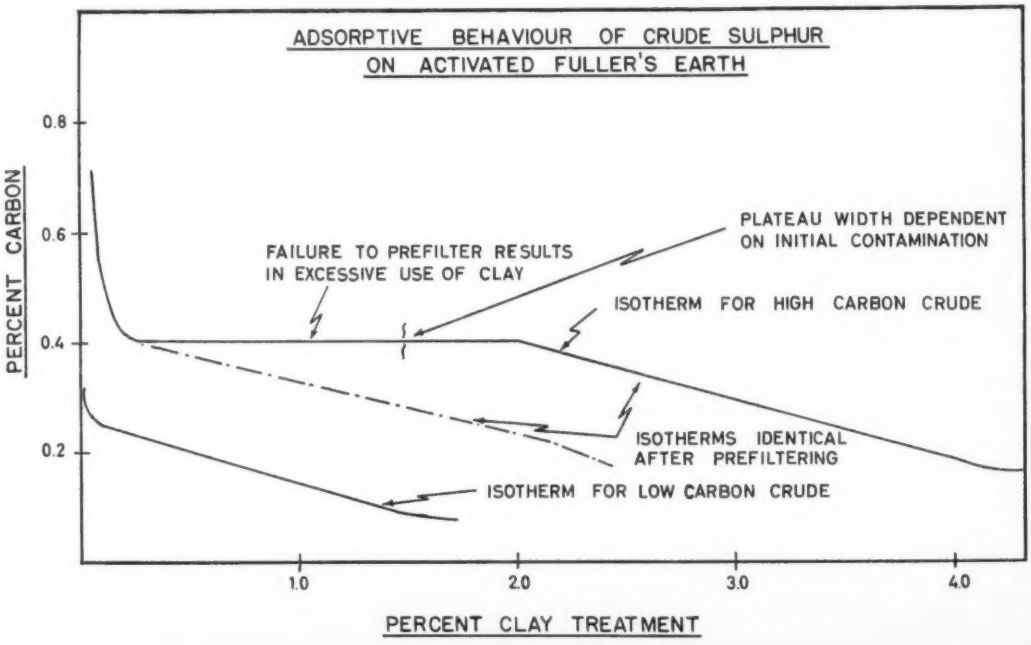


Fig. 4

Failure to prefilter the crude sulphur results in blinding the activated clay particles by the undissolved hydrocarbons and adsorption of the dissolved fraction does not commence until sufficient clay is added to remove thoroughly the undissolved hydrocarbons. Thus a prefiltering or straining step is dictated by economy.

This behaviour is shewn in Fig. 4. Variations from this behaviour from batch to batch are found because of a varying degree of solution of hydrocarbons. For practical purposes a dosage of clay is chosen to maintain an average output of the required quality, although specific batches may be as much as 20% higher or lower in carbon content of product.

The removal of colouring matter is closely associated with the carbon reduction, but in order to remove simultaneously the major portion of the discolouration, an extremely active clay is required. Industrial scale testing of almost all of the activated clays in the world shows that the number of suitable clays for sulphur purification is small. In practice, the colour of the product sulphur is not measured quantitatively because the colour is a property of secondary importance in the industrial uses of sulphur.

The equipment used at Jaltipan by Pan American Sulphur Company consists of six horizontal pressure leaf filters which have a total of 124 leaves with a filtering area of 3,360 sq. ft. Batch tanks of 20ft. x 20ft. x 7ft., made of steel plate, each equipped with a 7½-h.p. agitator and a 20-h.p. pump, are used for mixing clay and raw sulphur. The technique of operation is standard for this equipment, with air being used for cake blowing.

The operation is essentially trouble free. Corrosion and erosion of the leaves are avoided by maintaining long filter cycles and storage of out-of-service leaves in an oil bath. Screen service approximates 500 tons filtered per square foot before repair is necessary on the rim drainage type of leaf. This is approximately doubled for the rimless type draining over the whole area of the leaf.

Approximately two million tons of sulphur have to date been filtered in this installation.

(b) Acid Treating :

The purification of crude sulphur by sulphuric acid is similar to the acid treating of crude oil to improve colour. The acid, by sulphonation, oxidation and dehydration, serves to coke the unsaturated fractions and sulphonate the mercaptans and aromatics.

After treatment with acid a mixture of sulphonates, paraffins, coke and sulphuric acid remains in the sulphur. The purified sulphur can be separated from the mixture by centrifugal machines, if the sulphuric acid is present in sufficient excess to serve as solvent for the reaction products*.

In order to avoid a capital investment at an inopportune moment the same basic reaction was applied to the present filtering equipment at Jaltipan. This was done by decreasing the quantity of acid, adsorbing the slight excess on natural clay, and after filtering on a precoated leaf, treating with a small amount of activated clay to remove the "mahogany acids" imparting a red colour to the acid treated sulphur*.

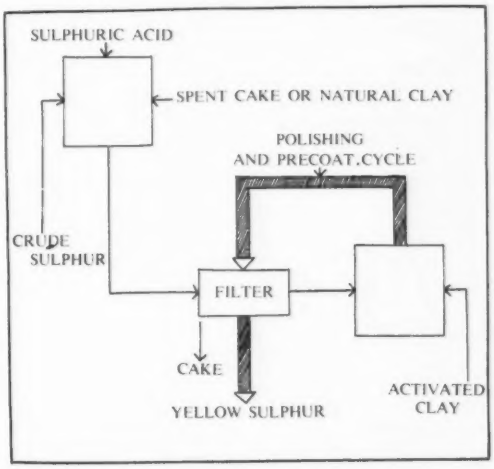


Fig. 5. Acid treating process.

Experience of many sulphur companies pointed towards the use of acids for purifying dark sulphur, but without commercial success, because of failure to recognise the difficulty of duplicating the conditions of mining in the laboratory,

* Patent assigned to Pan American Sulphur Company.

freshly produced sulphur having different properties than remelted material or that allowed to stand liquid for long periods. This change in properties is directly related to the extent of the zero order reaction between hydrocarbon and sulphur previously mentioned. Work done at Jaltipan indicates that carbon reduction and colour removal with acid and clay is critically associated with the mixing time of acid and crude sulphur. The quantity of excess acid is likewise critical. The present acid treating operation consists of mixing crude sulphur with somewhat less than 0.25% of 98% sulphuric acid for a period of 15 minutes. At this point, approximately 0.3% of natural clay is added to adsorb the sulphuric acid and part of the reaction products, effectively halting the sulphonation reaction. Excessive reaction time and also sulphuric acid in concentrates in excess of 98% produces sulphonates of dark colour which are difficult to adsorb even on an extremely active clay. After halting the sulphonation reaction, the mixture is filtered on a precoated screen and the filtrate treated with 0.08% activated clay to remove the easily adsorbed sulphonates. This second mixture is then filtered on a clean leaf to produce a yellow sulphur and leave an acid-free precoat on the screen for the first filtration operation. This technique avoids corrosion of filter screens. In Figure 5 this operation is illustrated.

UNITED KINGDOM SULPHUR

IN THE THIRD QUARTER of 1958 consumption by United Kingdom industry of sulphur in all forms amounted to 202,000 tons* representing a further decline of about 10,000 tons (5%) from the second quarter. Compared with the consumption of 225,000 tons in the corresponding period of 1957 this level represents a recession of 10%. It is evident that the customary seasonal decline was accentuated by the impact of lower overall industrial activity which was 3% lower than in the third quarter 1957.

The various Government measures to counter the fall in industrial activity had, by the end of the third quarter, not made much impact on the sulphur using industries and as the running down of stocks remained fairly widespread, the overall picture of activity tends to be patchy.

Consumption of imported brimstone and filter cake for sulphuric acid production was about 3% lower than the previous quarter. Much lower non-acid consumption reduced total brimstone consumption (10%) below the level during the third quarter of 1957.

Pyrites consumption further contracted as several pyrites burning plants were shut down or were being operated at a lower rate; reduced demand for acid, notably in the rayon and fertilizer industries, particularly affected this sector.

Consumption of spent oxide fell substantially owing to the severe decline of acid demand by the manufacturers of by-product ammonium sulphate. Low coke requirements due to the recession in the steel industry coupled with lower gas needs during the summer months, reflected on coke oven operations and thus the arising of by-product ammonia.

The fluctuations in the use of anhydrite—the third quarter's consumption is equal to 1,200 tons H_2SO_4 more than the second quarter but 2,600 tons less than the third quarter of 1957—are wholly attributable to the demands of maintenance and repairs. All three producers aim to operate their plants at peak rates and the use of 178,785 tons in the third quarter is estimated to represent about 96% of rated capacity.

Consumption of sulphur in zinc smelter gases showed a fractional increase over the previous quarter and is now 2% higher than in the third quarter of 1957. The higher consumption of zinc concentrates reflects the slightly improved sentiment in the nonferrous metal market.

* Does not include sulphur in anhydrite used for the direct manufacture of ammonium sulphate.

CONSUMPTION	3rd Quarter 1958	2nd Quarter 1958	% Change	3rd Quarter 1957	% Change
Elemental Sulphur:—					
Total Acid Sulphur	72,500	72,800	— ½	77,300	— 6¼
Imported	61,600	63,700	— 3¼	65,900	— 6½
Recovered, H_2S and filter cake	10,900	9,100	+ 19	11,400	— 5
Non-Acid Sulphur	21,000e	21,100e	— ½	27,000	— 22¼
Total Elemental Sulphur	93,500	93,900	— ½	104,300	— 10½
Pyrites	74,300	81,200	— 8½	85,900	— 13½
Spent Oxide	50,700	63,700	— 20½	58,900	— 14
Anhydrite	178,800	176,600	+ 1¼	183,600	— 2½
Zinc Concentrates	36,800	36,600	+ ½	36,100	+ 2

e = estimate

Supplies

In the third quarter imports of sulphur of 131,000 tons in the form of brimstone, filter cake and pyrites are comparable to, although lower than, the 141,000 tons sulphur imported in the corresponding quarter of 1957, whereas the preceding quarters imports of 99,000 tons, largely on account of changing shipping opportunities, were exceptionally low. Total brimstone imports of 96,000 tons originating almost exclusively from the United States (76,000 tons) and Mexico (19,000 tons) were 23,000 tons greater than those of the preceding quarter and were also slightly above the third quarter 1957 imports.

The average value of imports in the third quarter declined from £11 13s. in the preceding quarter to £11 3s. for U.S.A. material and £11 in the case of Mexican, indicative of the low Atlantic freight rates.

Pyrites imports of 78,015 tons were 26,000 tons greater than in the preceding quarter and compare with imports of 96,776 tons in the corresponding quarter of 1957. Imports from Canada totalled 20,886 tons compared with 5,300 tons in the second quarter. This material is at present, with low trans-Atlantic freights, being offered to United Kingdom consumers at very attractive prices which provide the main incentive for its purchase. With the cessation of shipments from Britannia Beach there is now no ice-free port for the shipment of Canadian pyrites during the winter and early spring, resulting in the need to build up sufficient stocks to last until shipments can recommence in the late spring. The other sources of pyrites, Cyprus (38,699 tons), Spain (13,413 tons), and Sweden (5,017 tons) all recorded increases compared with the second quarter.

Raw materials consumed for Sulphuric Acid manufacture.	*3rd Qtr. 1958* %	*2nd Qtr. 1958* %	*3rd Qtr. 1957* %
Elemental Sulphur :—			
Imported brimstone	34	33¼	33¼
Recovered, H_2S and filter cake	6	4¼	5¼
Sulphur in :—			
Pyrites	19½	20¼	20¼
Spent Oxide	13½	16	14½
Anhydrite	21	20	19¼
Zinc Concentrates	6	5¼	5½
Total (000 tons sulphur)	181	191	196

Sulphuric Acid Production

Total production of sulphuric acid (100% H_2SO_4) during the third quarter of 1958 amounted to 508,200 tons, a decline of 4½% from 531,900 tons in the second quarter and 7% from 545,800 tons in the corresponding period in 1957. This continued decline is attributable to the reduced level of activity in United Kingdom industry.

Only 71.7% of the total sulphuric acid capacity representing 709,160 (100% H_2SO_4) was utilized, compared with 75.9% in the preceding quarter and 78.2% in the third quarter of 1957. Overall installed capacity increased about 7,900 tons, but chamber capacity further declined to 151,380 tons of which 67.3% was utilized whilst contact capacity had increased to 557,780 tons of which 72.9% was utilized. The decline in chamber capacity reflects the final closure or maintenance shut-down of a number of pyrites roasting and spent oxide burning plants. No new plants came into operation during the quarter but the apparent increase represents the effect on capacity figures of plant which came on stream earlier in the year.

Sulphuric Acid Consumption

Total consumption of sulphuric acid in the third quarter of 515,441 tons (100% H_2SO_4) was 23,200 tons (4½%) lower than in the second quarter and 38,300 tons (7%) lower than the corresponding period of 1957.

The decline in sulphuric acid consumption has, with the exception of agriculture and

plastics, spread to all users. Principal changes in individual consuming industries compared with the third quarter of 1957 were as follows:—

	Change *000 tons* H_2SO_4	%
Rayon	−12.0	−18¼
Sulphate of Ammonia ...	− 9.0	−12
Titanium Dioxide	− 4.7	− 6
Iron Pickling	− 4.5	−15
Agricultural Purposes ...	+ 3.4	+92
Dyestuffs & Intermediates ...	− 3.2	−15¼
Sulphates of Copper, Nickel etc.	− 2.3	−48
Plastics	+ 2.0	+28½
Tar and Benzole	− 1.0	−14¼

Quantitively smaller, but nevertheless important changes occurred in bromine (+24%), paper (+28½%), hydrochloric acid (−12¼%), bichromates and chromic acid (−23½%).

Consumption of sulphuric acid for fertilizer manufacture declined by 5¾% compared with the third quarter of 1957. Demand started to improve in the latter part of September. Consumption of superphosphate has remained stable at a lower level whilst production of ammonium sulphate has started to regain its former position. Demand for the manufacture of titanium dioxide after a period of constant expansion has in recent months declined and sulphuric acid consumption is about 6% lower than in the corresponding quarter of 1957. This decline is mainly linked with lower pigment demands by the paint and paper industries. Laporte Titanium Limited have announced a substantial increase in titanium dioxide manufacturing capacity, and together with available facilities of British Titan Products, a substantial expansion of output may be expected as industrial activity accelerates.

The decline in consumption of acid by the rayon industry continues and is now approaching a level of 20% below the third quarter of 1957. The manufacturers of transparent paper owing to rapidly rising demand have significantly increased their consumption of sulphuric acid.

Non-acid Sulphur

Consumption of non-acid sulphur is still being profoundly affected by the low level of production and demand in the rayon industry, output of which for the first ten months of the year was running 18% below the corresponding period of 1958. In recent weeks

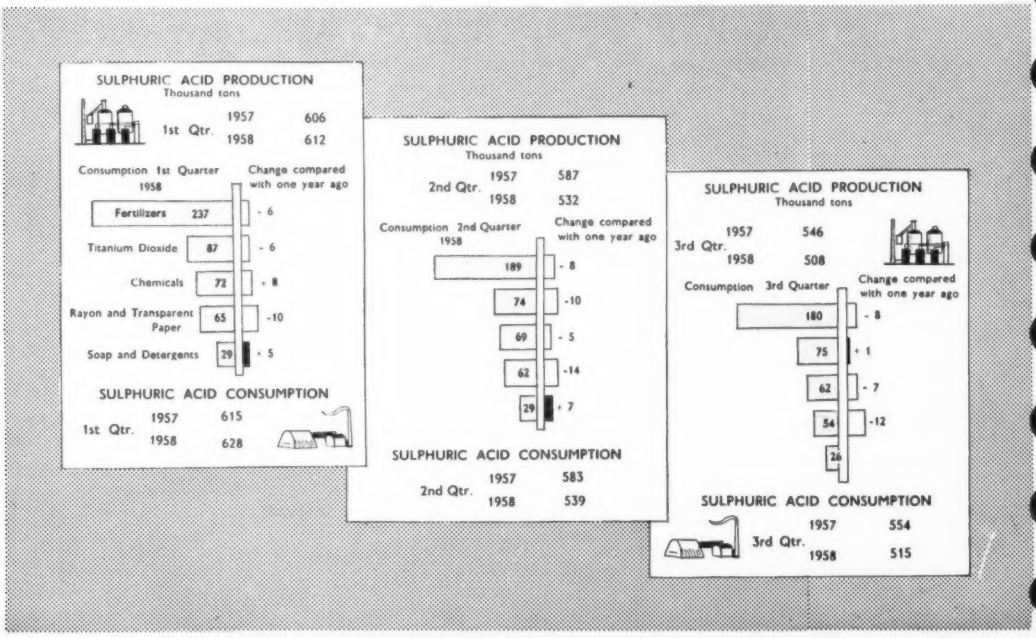


Fig. 6

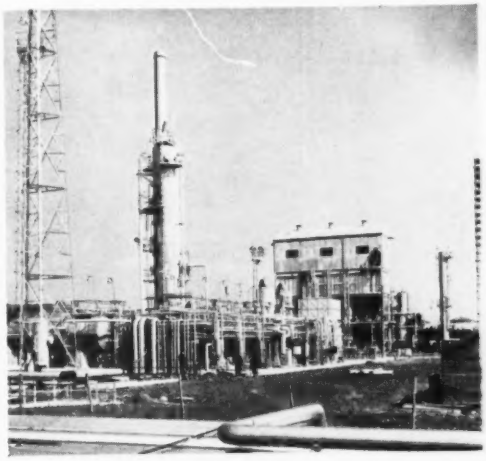
	Sulphuric Acid Consumption					
	3rd Qtr. 1958 000 tons	% Total	2nd Qtr. 1958 000 tons	% Total	3rd Qtr. 1957 000 tons	% Total
Fertilizers	180	34.9	189	35.1	188	34.0
Chemicals	62	12.0	69	12.8	61	11.0
Titanium dioxide	75	14.6	74	13.7	82	14.9
Rayon and Transparent Paper ...	54	10.5	62	11.5	66	11.9
Metallurgy	27	5.3	30	5.6	31	5.7
Oil Refining	13	2.5	12	2.2	15	2.7
Dyes	18	3.5	19	3.5	21	3.8
Soaps and Detergents	26	5.1	29	5.4	26	4.8
Plastics	9	1.7	10	1.9	7	1.3
Miscellaneous	51	9.9	45	8.3	57	9.9
Total	515	100.0	539	100.0	554	100.0

there has been a slight improvement in the position but there remains severe competition from other man-made fibres and overseas rayon producers. Demand from the rubber industry remains buoyant as are other non-acid sulphur users particularly sulphur dioxide and sulphites.

Conclusion

During the greater part of 1958 the United Kingdom sulphur and sulphuric acid industries have been operating substantially below 1957, by as much as 10%.

During the autumn months activity has revived and it is believed that by the close of the year the sulphuric acid sector as a whole will be only about 2% below the corresponding period of 1957. As yet there are considerable differences in the levels of activity between different branches of the sulphur industry, particularly on account of the varying effects and duration of running down stocks. Government financial measures have not yet made their full impact on the situation but this is expected to bring all round improvement in activity and become pronounced as 1959 advances. In the sulphur industry this should be reflected in a higher level of sulphuric acid production for which existing capacity and two projects in hand are more than adequate. The difficulties of the rayon industry are not likely to find an early solution and consequently little change can be expected in the overall demand for non-acid sulphur. The increased competition between brimstone suppliers coupled with low volume of freight rates, continues to benefit consumers. Following the satisfactory trial shipments of French recovered sulphur a substantial volume is to be imported in 1959, whilst Mexican and especially U.S. sulphur shippers endeavour to retain as great a share as possible of the U.K. market, the third largest in the world. The satisfactory performance of most of the modern U.K. flash roasters provides a nucleus of pyrites using capacity which, especially following the recent price reduction of European



British Petroleum Co. General view of 45 tons per day sulphur recovery plant at Isle of Grain (Kent) refinery.

pyrites, is not expected to abandon this source of sulphur supply in the foreseeable future. The increased use of copperas as a by-product of titanium oxide and steel pickling is, with the aid of fluidised bed roasters at British Titan Products and National Smelting Corporation, promising to become a significant source of by-product sulphur for acid manufacture. With expansion of sulphuric acid production a clear pattern of sulphur usage may be expected to emerge.

Laporte Industries Limited

SEVENTY YEARS have passed since Bernard Laporte started the manufacture of hydrogen peroxide at Shipley in Yorkshire. Today, Laporte Industries Limited is a large group of ten subsidiary and associated companies producing a wide range of chemicals. Of these, sulphuric acid is among the most important, the annual level of production now being at the rate of one quarter of a million tons (100% H_2SO_4), and is produced by three subsidiaries of the Laporte Group, whose activities are detailed below. The current sulphur requirements are about 40,000 tons brimstone, 15,000 tons spent oxide and 60,000 tons pyrites per annum.

Other products of the Laporte Group include hydrogen peroxide, titanium oxide, Fullers earth, barium products, detergents, sodium sulphide, sodium sulphate and sulphide of iron.

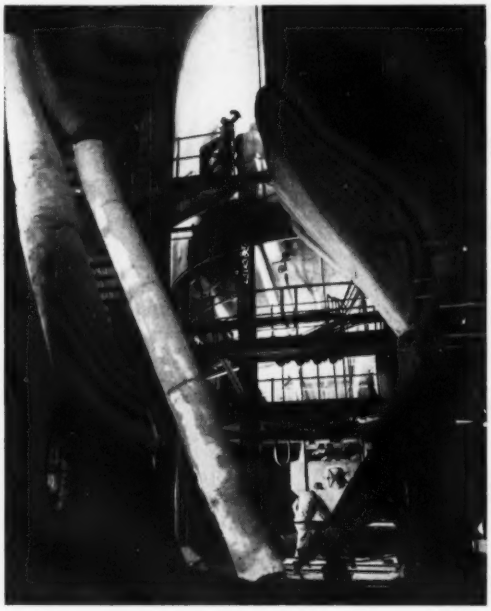
LAPORTE ACIDS LIMITED

Laporte Acids Limited is a merger of three old-established Yorkshire firms, the first to be incorporated into the Laporte Group in 1946 was *John Nicholson & Sons Limited*, whose Hunslet Chemical works at Leeds include the original site of operations extending over 150 years.

Throughout their history, the main interest of John Nicholson & Sons Limited was in the production of sulphuric acid, which in 1894 was being produced in three chamber plants burning pyrites; in 1896 the use of pyrites was extended to the manufacture of iron sulphide from scrap iron, and in 1919 extended to brimstone in order to give a high quality non-arsenical acid, and at about this time a change was made in the manufacture of the nitric oxides required for the chamber plant. Previously produced from nitrate of soda, these were now made by the oxidation of ammonia. A plant for the manufacture of refined, rolled sulphur was also built.

The first contact plant producing all strengths up to 65's Oleum was built in 1940. This was followed by a second contact unit built in 1944, based on brimstone and supplying the highest grades of pure acid. In 1954 the range was extended to the production of sodium sulphite and sodium thiosulphite from the sulphur dioxide in the exit gases of the contact plant.

Another old-established business acquired by Laporte Acids Limited was that of *Hunt Brothers (Castleford) Limited*, whose Aire & Calder Chemical Works at Castleford, covering a site of about 40 acres, were taken over in 1949. Built in the middle of the last century, these works were primarily used to manufacture bleaching powder for export. The hydrochloric acid required was made from salt and sulphuric acid, the latter being prepared from pyrites and spent oxide by the chamber process. These works also made glue and size, using hydrochloric acid and sodium sulphide, while sodium sulphate and sodium carbonate were also made.



One of the Flash Roasters serving the 100 tons per day contact plant at Castleford.

At the turn of the century, the export of bleaching powder was found to be no longer profitable, and its manufacture was discontinued. Since then, sulphuric acid has been the principal product of the Aire & Calder

Works, which also manufacture hydrochloric acid, saltcake and Glauber's salt. Formerly, the bulk of the sulphuric acid production was based on the use of brimstone, but as a result of the sulphur shortage of 1950 the company diversified its supplies of sulphurous raw materials and furnaces were installed to burn spent oxide. About 1954, in order to meet an increasing demand for sulphuric acid, a pyrites contact plant with flash roaster furnaces and electro-static cleaning equipment was erected to produce over 100 tons of sulphuric acid daily.

The Westgate Chemical Works at Cleckheaton, Yorkshire, formerly operated by the *Cleckheaton Chemical Company Limited and the Bierley Chemical Company*, were taken over by Laporte Acids Limited in 1954.

With the Hunslet, Castleford and Cleckheaton Works, Laporte Acids are in an excellent geographical position to supply the needs of Yorkshire textiles and other industries. Sulphuric acid is being produced by both contact and chamber processes from brimstone, pyrites and spent oxide.

Laporte Titanium Limited. View of Stallingborough sulphuric acid plant.

LAPORTE TITANIUM LIMITED

This company, formerly known as National Titanium Pigments Limited, became the first manufacturer of titanium oxide on a commercial scale within the British Commonwealth when a pilot plant was built at Barking in 1927. Aware of its importance in the manufacture of paint, ceramics, linoleum, rubber, plastics, rayons, cement, paper and

soap, Laporte Titanium have greatly increased their production.

Titanium oxide is made from ilmenite, a mineral imported from Scandinavia, South Africa and Malaya, and sulphuric acid. To produce their own requirements of sulphuric acid, in 1953 the company erected a pyrites flash roaster at their works at Stallingborough. This unit is similar to that built at the Castleford works. To meet the demands of their increased production of titanium oxide, a sulphur burning contact acid plant, built by Simon-Carves Limited and with a capacity of 175 tons per day, has been commissioned at Stallingborough this year. With this plant in operation, Laporte Titanium Limited are independent of external supplies of sulphuric acid, much of which they previously bought from Laporte Acids Limited. The latter are consequently closing down some of their older units, thus achieving greater economy of operation.

LAPORTE CHEMICALS LIMITED

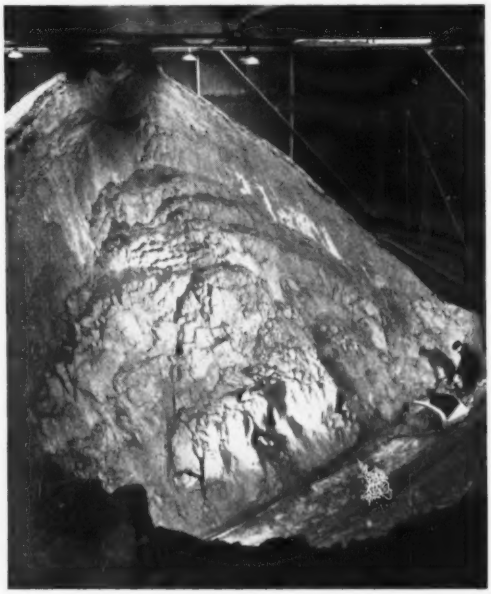
This subsidiary of the Laporte Group of companies also manufactures sulphuric acid. The firm, which changed its name from B. Laporte Limited in 1948, has since 1898 centred its activities on Luton, where hydrogen peroxide continues to be its principal product. Laporte Chemicals Limited are also carrying on extensive operations at their Baronet Works at Warrington, where a plant has recently been installed to make hydrogen peroxide by a new organic method.

As they use considerable quantities of sulphuric acid in the manufacture of several of their many products this company installed a Leonard-Monsanto brimstone burning acid plant at their Luton works in 1941. This plant, using the contact process, has a capacity of 50 tons (100% H_2SO_4) per day.

In addition to hydrogen peroxide and sulphuric acid of all strengths, Laporte Chemicals Limited manufacture a wide range of chemical products including sodium perborate, ammonium persulphate, barium chemicals, organic peroxy-compounds and detergents.

Future Outlook

The bold policy followed by Laporte Industries Limited in expanding their production of titanium oxide has been reflected in the increased importance attached to the manufacture of sulphuric acid. Although modern technical developments in the recovery of the sulphur radicle of the copperas may eventually reduce the overall acid requirements of this sector of the industry, the prominent part played by the group in the manufacture of sulphuric acid, of which they are now the third largest producer in Great Britain, can be expected to continue. Not only is it used by the companies of the group in large quantities and for a wide variety of purposes, but there is an important market for it in Yorkshire and the North-East of England, and Laporte maintains a fleet of road and rail tankers to deliver sulphuric acid to consumers over a wide area.



Pyrites storage at Castleford of Laporte Acids Limited.

The Laporte Group of companies, including subsidiaries in Australia and Canada, have a combined capital exceeding £11 million, and continue to follow a policy of steady expansion. The considerable expenditure by Laporte Industries Limited in recent years on research and development can be expected to pay a handsome reward and should enhance their valuable contribution to British economy.

Sulphur in Communist Countries

BULGARIA

Production of sulphuric acid in 1957 is reported to have totalled 40,400 tons as compared to 28,600 tons in the previous year. Under the current Five-Year Plan—Bulgaria's third—when preference is being given to the chemicals and chemical fertilizer sectors of the industry, sulphuric acid production is planned to expand spectacularly. The Dimitrovgrad Chemical Combine, where operation of the superphosphate plant started recently, plays a key rôle in the plan. The 1962 target for phosphatic fertilizers has been set at 560,000 tons and 330,000 tons for nitrogenous fertilizers. The original plan for sulphuric acid, which foresaw the manufacture of 290,000 tons by 1962, has recently been superseded by a revised Four-Year Plan which aims at 300,000 tons by 1961. The principal expansion is scheduled to take place at the integrated chemical works at Dimitrovgrad where it is believed sulphuric acid capacity will be enlarged to over 150,000 tons. Fertilizer production at this plant alone is to be raised from the present capacity of 100,000 tons superphosphate to 400,000 tons. The first section of the nitrogenous fertilizer plant was commissioned earlier this year and this is designed to produce 300,000 tons of nitrogenous fertilizer by 1963, the bulk of which will be in the form of ammonium nitrate. It is not known whether ammonium sulphate production is to be expanded.

New developments include the construction of a copper smelter at Pirlop due to be completed early in 1959. This plant has a capacity of 8,000 tons per annum of electrolytic copper and incorporates an integrated by-product sulphuric acid plant with an annual capacity of 23,000 tons (100 % H_2SO_4). The copper sulphate plant (10,000 tons per annum) and the power plant were completed earlier this year.

General view of the "Stalin" chemical and fertilizer plant at Dimitrovgrad.

Based on pyrites the sulphuric acid industry is to remain dependent on this raw material although the construction of by-product sulphuric acid plants at smelters, as at Pirlop, will form an integral part of new chemo-metallurgical plants. It is unlikely that sulphur will be used to manufacture sulphuric acid and the present small output is likely to be directed to non-acid uses only. Production, which commenced in the summer of 1955 after pilot plant operations lasting nearly two years, is at an annual level of 2,200 tons. In 1956 it was reported that 1,989 tons were exported.

Production of all types of fertilizers in the first six months of 1958 is officially reported at an annual rate of 340,000 tons (140,000 tons in 1957).

CHINA

The reported intensive level of plant construction in the Chinese chemical fertilizer industry would seem to make the production target of between five and seven million tons of fertilizers by the end of the second Five Year Plan—1962—realistic. Although current consumption of chemical fertilizers is running at a level of one million tons, this figure is being supplemented by large quantities of "green" and farmyard manure.

The erection of large fertilizer units in agricultural areas where raw materials are in favourable supply are a feature of the Five Year Plans. Notable projects on which work has commenced are the fertilizer plant in Honang Province at Kaifeng, which has an annual capacity of one million tons, and which will incorporate a triple superphosphate unit of 200,000 tons, and the plant at Kweiyang, Kweichow Province, the capacity of which will amount to 400,000 tons ammonium sulphate and 200,000 tons calcium superphosphate. It is reported that partial operation of this plant and the large triple superphosphate plant at Kunming, Yunnan Province, will commence in 1959. Another outstanding project is located in Anhwei Province. This is to have an ultimate capacity of 840,000 tons ammonium sulphate; it is anticipated the first half of the plant will be in operation in 1960. Phosphatic fertilizer plants have also been commissioned at Taiyuan, Shanshi Province and at Nanking. The latter has a capacity to produce 200,000 tons granulated superphosphate, and was officially opened in March 1958. At present, China's two principal fertilizer plants responsible for the bulk of fertilizer production, namely the Yung li Chemical Works at Nanking, and the Dairen Chemical Works, Manchuria, are also undergoing expansion. To the former plant, whence output in 1957 was about 170,000 tons, is to be added a new 80,000 tons per annum ammonium sulphate plant of Czech origin, while at Dairen an expansion is under way to treble capacity to 800,000 tons.

At Nanking and Dairen production of ammonium sulphate is based on the traditional process of sulphuric acid. It is believed that the new plants to be built will employ the direct anhydrite/carbon dioxide process. The sulphuric acid requirements of the superphosphate plants are to be based on the exploitation of large local deposits of pyrites.

The exploitation of the deposits of native sulphur are reported to be increasing. A sulphur plant with a capacity of 50,000 tons is expected to commence operations early in 1959 in the Chilien Mountains, Kansu Province. It is estimated that in 1957 Chinese production of elemental sulphur amounted to 130,000 tons.

CZECHOSLOVAKIA

In common with other Communist countries, Czechoslovakia is making a determined effort to expand chemical and fertilizer production in order that her agriculture may receive sufficient plant food without having to depend on imports. At present consumption is 68.9 kilos of fertilizer per hectare, while the present target envisages the use of 160 kilos per hectare by 1965.

Emphasis is being placed on the production of nitrogenous and phosphatic fertilizers not requiring sulphuric acid in their manufacture. Notable developments in this field have been the commissioning of a new fertilizer unit to produce 40,000 tons per annum thermo-phosphate at the Dimitrov Chemical Works in Bratislava. Produced by thermal decomposition at high temperatures and rapid cooling, it is claimed that the P_2O_5 content is in a readily available form. At present under construction near Sala, on the Vah River, is the Duslo Chemical Works, which is to produce nitrogenous fertilizers. This plant, designed to enter operation in 1963, will be based on the synthesis of natural gas and is believed to have an annual capacity of about one-half million

tons. Two further fertilizer plants are reported to be under erection at Michalovce and Shuran.

Plans for the expansion of the sulphuric acid industry have recently been revised in view of the development of the Polish elemental sulphur industry. It is foreseen that production of sulphuric acid in 1960 will be 560,000 tons, of which 100,000 tons is to be based on Polish brimstone.

A development of particular significance to the Czechoslovakian sulphur industry is the exploitation of the low-grade lignite deposits on the River Elbe, close to the East German frontier. Probably the largest deposit of its kind in Europe, the new exploitation plans include the erection of a gas works capable of producing some 475 million cubic metres of gas per year and a by-products plant for the production of some 100,000 tons per year of tar, crude oil and other chemicals. The project is scheduled for completion in 1961 and, being based on lines similar to the East German lignite processing plants, this unit could make a valuable contribution to the Czechoslovakian sulphur industry by providing a new source of sulphur in the form of elemental sulphur, by-product sulphuric acid or ammonium sulphate.

In 1957 the level of sulphuric acid consumption was 450,000 tons. Of this total it is estimated that about 25% of acid is consumed by the fertilizer industry, while the bulk (55%) is consumed in iron and steel pickling, petroleum refining and the textile industry; the remainder is used for general industrial purposes. The construction of a new synthetic detergent plant represents a new call on sulphuric acid supplies and will increase the incentive to boost the sulphuric acid capacity and output.

EAST GERMANY

The rapidly rising volume of domestic production and trade with members of Communist countries has made E. Germany one of the most important industrial countries of the Soviet Bloc. Germany is now Russia's largest trading partner and China's second, in contrast with W. Germany with whom trade has fallen to a record low level.

Since partition in 1945 Eastern Germany's chemical industry has felt the lack of a sufficient volume of sulphuric acid capacity and in remedying this, emphasis has been placed on the development of indigenous sulphurous raw materials for use in the manufacture of sulphuric acid. At present about 50% of sulphuric acid production is based on imported pyrites and although imports will continue to rise, the rate of increase will be considerably reduced when the anhydrite plant at Coswig enters production at an annual rate of 100,000 tons SO_3. Domestic pyrites originate from a small deposit at Elbingerode (Harz) and one in the Freiburg district, but because of their poor quality, they are mixed with imported pyrites. Other domestic sources of sulphur are metal smelter gases from which an annual production of about 80,000 tons sulphuric acid is derived and magnesium sulphate, which yields a similar total. In 1957 these two sources accounted for 14% of sulphuric acid production and no increase in this percentage is foreseen.

During 1958 H_2SO_4 capacity was expanded by an additional 60,000 tons (SO_3) as the result of the commissioning of three plants: at the Ferd. Runge Chemical Works at Oranienburg a second tower plant was installed; at the Salzwedel superphosphate plant, formerly operated by Wasag, sulphuric acid and superphosphate capacity has been doubled to 20,000 tons (SO_3) and 30,000 tons superphosphates respectively. This plant is also based on the tower process and uses pyrites. At the Kunstseidenwerke Fz. Engels at Premnitz an additional acid plant with a capacity of 22,000 tons per annum has been erected in conjunction with a fluidized bed roaster using low-grade pyrites. It is anticipated that in 1959 acid capacity will be supplemented by the Coswig anhydrite plant and a new plant to be built for Freiberger Bleihütte with an annual capacity of 60,000 tons SO_3.

Production of sulphur, which is recovered from H_2S arising in the processing of lignite at Leunawerke, totalled 101,789 tons in 1957, about 7,500 tons more than in the previous year. There are no immediate plans for expanding the present sulphur capacity although, depending on the type of crude oil to be imported at an annual rate of five million tons by the projected pipelines from the U.S.S.R., the planned oil refinery and petrochemical plant may give rise to sulphur recovery.

In the reorganisation of the East German economy the Ministry of Chemical Industry has been disbanded and its place taken by the formation of seven "Vereinigungen Volkseigener Betriebe" or V.V.B. This horizontal integration of the chemical industry places the responsibility of the production, planning, materials supply, labour, research, etc., within the appropriate sector of each V.V.B. The V.V.B. for General Chemicals includes 33 subordinate factories with a labour force of 26,000 and the major are sulphuric acid, phosphoric acid, fertilizers, insecticides, detergents, technical gases and dyestuffs. It is intended that this approach to the chemical industry wil help to prevent delays in planning and production stages and ensure that adequate capacity is available. In the sulphuric acid sector only 77% of output is under V.V.B. control.

The rise of 12% in East German industrial production in 1958 is a measure of the rapid advance in the country's industrial sector and its volume and diversity of production places East Germany in a prominent place in Europe as a whole. The series of Five-Year Plans of industrial expansions are expected to make a special impact on the chemical industry and on the sulphur and allied industries in particular. Emphasis on sulphuric acid is evident from the targets which have been set at 610,000 tons SO_3 for 1965 and one million tons for 1970.

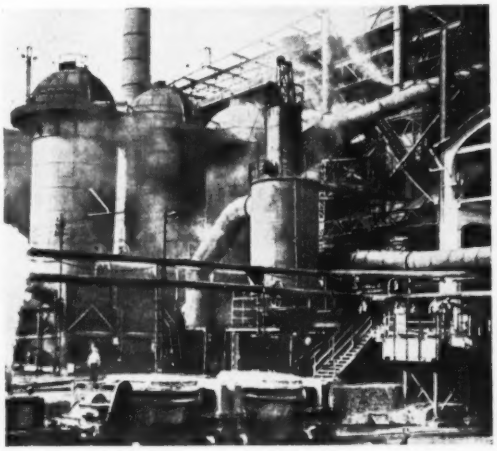
HUNGARY

The rapid development of the Hungarian chemical and fertilizer industry since 1945 is the more impressive because its pre-war activities were narrowly limited. The substantial financial credit which has been made available by the Soviet Union has been primarily directed to the chemical and fertilizer sectors which are especially important, in view of the Government concern over low crop yields. Of the four major fertilizer plants which have been planned, the first unit is now in operation. This is the Borsod Chemical Works (Kazincbarcika) which commenced trial operations in May and was in full production in September. Its capacity is 120,000 tons per annum of nitrogenous fertilizers and production at this plant during 1958 is expected to reach 50,000 tons.

The target for 1960 is one million tons of all types of fertilizers of which two-thirds are to be nitrogenous. The superphosphate and sulphuric acid plant at Szolnok is undergoing a major expansion to double capacity which it is planned to complete by 1960. Expansion is also foreseen in the sulphuric acid sector whose output — 115,000 tons H_2SO_4 in 1957 — is derived from plants at Budapest, Peremarton, Szolnok and Tiszapalkonya.

RUMANIA

The rapid industrialisation of Rumanian industry since 1946 has been followed by the establishment of a chemical industry. This has been based on the important sweet crude oil and natural gas deposits and extended over a wide range of chemicals including plastics, synthetic fibres, rubber, insecticides, drugs, detergents, emulsifiers, etc. Methane gas, which occurs in the Transylvanian plateau, is processed into ammonia for use in the two local nitrogenous fertilizer plants. Likewise at the Hunedoara steel works, in addition to the production of sulphur, ammonium sulphate and carbon disulphide, a whole range of coal chemicals are recovered.



Blast furnaces at the Hunedoara steel works. Sulphur, carbon disulphide and ammonium sulphate are recovered at this plant.

Sulphuric acid production has risen rapidly since 1949 when production was only 34,000 tons compared with 45,000 tons in 1938. Plant destroyed during the war was repaired and production rose to 51,600 tons in 1950 and 92,000 tons in 1955. The new acid plants are

associated with the superphosphate projects notably at Petru Poni and Navodari, and the first project is now in partial operation. At Petru Poni the initial development permits the annual production of 100,000 tons superphosphate and machinery has been installed for the granulation of 50,000 tons—the first installation of its kind in the country.

Targets to be met by the fertilizer industry call for the production of some 625,000 tons of all types of fertilizers and involve an investment of 600 million lei. The 1960 target for sulphuric acid is set at 210,000 tons H_2SO_4. Whilst the main emphasis is placed on the production of phosphatic fertilizers a major new nitrogen plant is under construction at Savinesti with an annual capacity of 210,000 tons nitrogenous fertilizers.

POLAND

Production targets for the chemical industry in 1960 and 1965 were published recently and were compared with production for 1958.

The official report recognises that the production of both sulphuric acid and nitrogenous fertilizers has fallen behind the original planned targets necessitating a reappraisal in order to make the targets for 1960 and 1965 realistic. Thus the target for sulphuric acid output in 1960 has been lowered by 55,000 tons and that

	1958	*1960*	*1965*
	000 metric tons		
Elemental Sulphur ...	5	30	400
Sulphuric Acid (100%) ...	573	668	1,060
Nitrate fertilizers (N) ...	235	270	480
Phosphatic fertilizers (P_2O_5)	157	226	360
Potassic fertilizers (K_2O) ...	—	—	60

for nitrogenous fertilizer lowered by 28,000 tons (N content). Nevertheless, the rapid growth of Poland's sulphuric acid production and consumption merited the expression of official satisfaction and the current consumption of 17.6 kilos per capita reflects an expansion of some 330% since 1937. It is anticipated that this figure will be doubled by 1965.

Of the 4,000 million zlotys which have been allocated to Polish chemical industry for 1959, a substantial portion has been allotted to the sulphur combine. Its development has, however, been subject to considerable delays, mainly due to shortage of labour and lack of

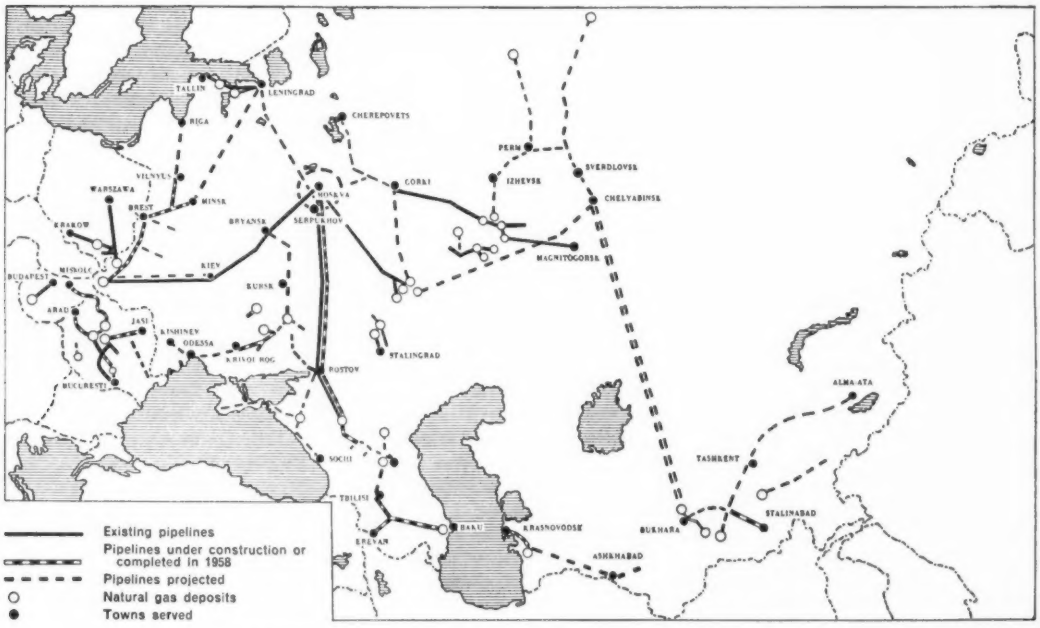
Oil/Gas separation plant at a recently developed oil field on the Caspian coast.

mechanical power and although the Piaszeczno mine is scheduled to be extracting 180,000 tons of ore in 1959, it is doubtful whether sufficient overburden will have been removed with the limited resources. Additional equipment has been allocated to the ore concentration plant at Tarnobrzeg to speed erection of the plant. Construction work has also commenced on the sulphuric acid plant which will have an initial capacity of 100,000 tons rising to 600,000 tons by 1965, and will be used for superphosphate production.

U.S.S.R.

Recent developments in the Soviet Union further underline the importance attached to increasing production of fertilizers and the raw materials upon which they are based, notably in the Republics of southern Central Asia. It appears that more effort is now being concentrated in these areas in order to obtain quicker results at the expense of the longer term and much publicized schemes for Siberian agriculture, from which returns have so far been disappointing. According to official sources, production of fertilizers of all types for the first nine months of 1958 totalled 9,200,000 tons compared with 8,636,000 tons in the corresponding period of 1957. At the end of September it was claimed that the planned output had been exceeded by 436,000 tons, which seems to indicate that, in view of plant re-organization, the original plan had allowed for only a slight increase over 1957. Production of chemical fertilizers in 1958 is not expected to exceed 13 million tons and at this rate it will not be keeping pace with agricultural expansion.

In pointing to these apparent shortcomings in the expansion of the Soviet fertilizer and sulphuric acid industries, it is as well to remember the scale of the programme. Related to the United Kingdom fertilizer industry, the increase in Soviet production of fertilizers expected between 1957 and 1958 represents one year's entire output of United Kingdom superphosphate producers.



Natural gas pipelines in the Soviet Union and Eastern Europe.

In the Drogobych district of the Ukraine where there are large deposits of sulphur, the melting section of the Rogdolaky Sulphur Works has started working. Production from these deposits will be used to supply the chain of fertilizer and sulphuric acid plants being built on the shores of the Black Sea.

The greatest number of projects currently being developed are in Southern Central Asia

and the Ural Mountains. In the Republic of Uzbekistan, a nitrate fertilizer factory is to be built in conjunction with the natural gas pipeline from Bukhowa to Tazhkent. In Tazhkent itself the Chirchik Electro-Chemical Works will change over to operating on natural gas thereby, it is reported, considerably reducing costs of fertilizer production which in 1959 will include a new nitrogen-phosphate compound which has been developed by the Uzbek Academy of Science and may use furnace phosphate. Also in Uzbekistan deposits of potash, in the form of carnallite and sylvanite, and anhydrite have been discovered.

Deposits of sulphur have been opened up in Tazikistan (Tadzhik) and it is planned to establish a nitrogenous fertilizer factory there probably making ammonium sulphate.

The largest sulphur works in the U.S.S.R. is stated to be located in the Gissar Range of south-east Turkmenistan. A number of production units have already been built and the concentration plant has commenced production. The new superphosphate factory being built at Charjou (Chardzhou) on the banks of the River Amu will probably utilize the Turkmenistan sulphur and phosphate from the Kara Tau deposits. Also using sulphuric acid a detergent plant is being constructed at Krasnovodsk on the shores of the Caspian Sea.

In Armenia utilization of natural gas piped from Karadag in Azerbaizan is intended to treble the output volume of the chemical industry. A large part of this gas will be processed to make ammonia. Also mining and chemical works are to be constructed at Akhta for the production of potash. The Sumgait superphosphate plant will increase its output of superphosphate, sulphuric acid, anhydrite and other chemicals, and it is evident that supplies of sulphurous raw materials will have to be expanded.

In the Ural Mountains production of nitrogenous and phosphatic fertilizers is scheduled to be greatly increased. However, at Berezniki construction of a large potassium combine is behind schedule, and also the plan to build a number of sulphuric acid plants, essential to further development, is reported to be progressing only slowly.

It is apparent that slow development of the sulphuric acid industry is still putting a serious brake on the growth of Soviet industry in the development areas, particularly affecting fertilizer production. For this reason effort is being concentrated in certain more favourable areas where, with large integrated projects covering a wide chemical and metallurgical field, the best possible use can be made of ancillary services.

San Telmo Iberica Minera S.A.

The San Telmo group of three pyrite masses lie in the Province of Huelva, and is connected to the railway junction at Val de la Musa on the Zafra Huelva Railway by 11 kilometres of narrow gauge line. Outcrops within the concession area were first exploited by heap roasting and leaching between 1860 and 1890 by the Bede Metal Company. However, despite continued efforts by the owners no successful method of production was evolved until 1927, when they erected a plant for the treatment of the complex ore by flotation. San Telmo Iberica Minera S.A. took over the mine in 1946 after it had been closed for some years.

The ore body from which the main production occurs to-day is the "Santa Barbara" mass which consists of three main groups—the complex ore with as much as 20% Zn, 3% Cu, and 35% S, the iron pyrites with an average of 48% S and O.12% As, and Cupreous Pyrites with approximately 47% S and 2% Cu. The proved reserves of the " Santa-Barbara " mass are estimated at 5.5 million tons with a further probable 2.5 million tons.

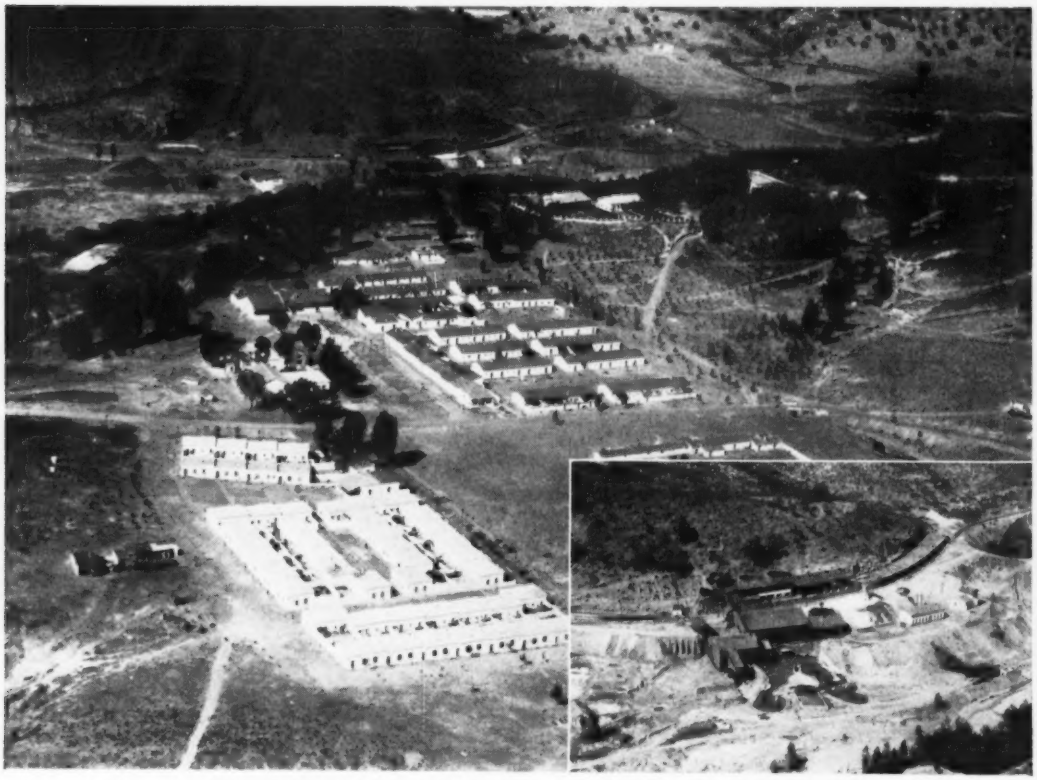
San Telmo Iberica Minera S.A. produce three types of ore, crude, cupreous and flotation which analyse as follows:—

	Crude	*Flotation*	*Cupreous*
	%	%	%
Sulphur	48.05	48.32	48.27
Iron	41.97	42.05	43.27
Copper	0.69	0.56	2.03
Arsenic	0.12	0.12	0.01
Lead	0.09	Traces	0.007
Zinc	0.47	0.53	Nil
Selenium	0.020	0.016	Nil
Silica	3.01	1.88	1.32
Silver oz. per ton	0.27	0.66	1.6955
Gold oz. per ton ...	0.016	Nil	0.0245

The capacity of the mine which up to now has been producing at the annual rate of 50,000 tons has recently been expanded by the sinking of a new shaft to a depth of 190 metres. This was completed in mid-1958 and has raised the annual capacity to 150,000 tons, whereas present annual capacity is approximately 90,000 tons. An innovation is the shunting and tipping of two wagons which are brought up in a cage to a height of 11 metres, before discharging their load of three tons into two hoppers, which feed the "Babbitless" crushing plant. This plant consists of one screen and three rotary crushers. Ore is transported by the Zafra railway to Huelva where the company ships from the north pier. They have similar facilities to those of the large mines and are capable of loading up to 1,000 tons daily.

Approximately 25,000 tons of cupreous ore are shipped annually to Germany in addition to crude ore deliveries to Belgium, France and Italy and some flotation concentrates to France. Although small sales were made to the U.K. in 1951 and 1952, no further exports to this country have been made. Only crude pyrites and flotation concentrates are delivered to consumers in Spain.

San Telmo Iberica Minera S.A. is one of the few Spanish producers with low arsenical ores, containing no more than 0.12% arsenic. The ore is favoured by many producers on account of its good roasting properties and the satisfactory residues which it yields.



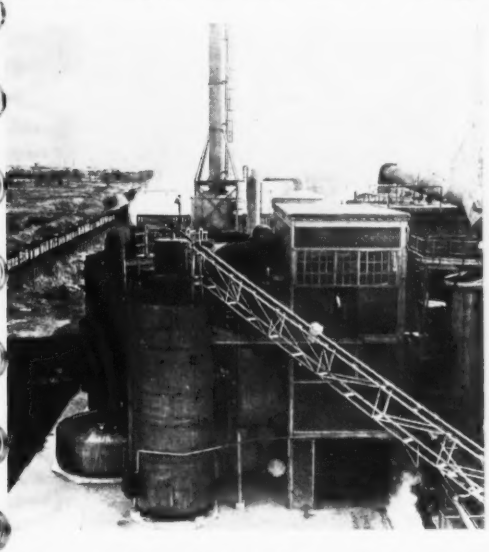
San Telmo. Miners' village. Crushing, screening, ore treatment plants and rail loading facilities in background; see also inset.

Current Events

UNITED KINGDOM

Fisons Limited—Annual Report

Sir Clavering Fison, Chairman of *Fisons Limited*, in his annual report for the year ending June 30th, 1958, referred to the reorganisation that has taken place within the group. This has involved the formation of two divisions, namely Fertilizers and Chemicals. The former embodies all Fisons' interests in the fertilizer field in the United Kingdom and overseas countries, notably Canada, South Africa and Rhodesia. The Chairman stated that it was clear that there had been another substantial increase in the total tonnage of plant food consumed in the United Kingdom. This had brought Fisons' deliveries for the year ending June 1958 to the highest point yet achieved, despite the fact that the acreage



New plant at Immingham. L. to R. hot gas filter, convertor, sulphur burner, absorption tower and boiler house.

under arable cultivation had remained approximately the same. Developments in the year included the introduction of a new fertilizer range known as "41," on account of the demand for more concentrated products. During the year a second brimstone sulphuric acid plant was commissioned at Immingham which the Chairman believed to be among the most economical in the country.

In addition the new nitrogen factory at Stanford-le-Hope is nearing completion and it is expected to come on stream early in 1959. The factory is to produce 140,000 tons of ammonium nitrate per year, which will be despatched in a hot solution of 86% concentration to the Group's existing fertilizer works in various parts of the country.

The Chemical Division, which embraces the majority of the subsidiary companies, had shown a profitable year, despite the necessity to close down the Fulham works of Messrs. Whiffen & Sons. This was brought about by the general decline in business in pharmaceutical chemicals. The more compact new organisation centred on Loughborough leaves room for further expansion when it becomes expedient to do so.

Total Group sales at £47,391,000 have risen over £2.5 million since the previous year, and the trading profit before taxation was £3,142,000 compared with £3,095,000, an increase of £47,000.

More Anhydrite Acid

The Board of *Solway Chemicals Limited* announced their decision to expand the anhydrite acid plant at Whitehaven. Inaugurated in 1955 the present plant has a rated annual capacity of 100,000 tons (100% H_2SO_4) and a similar quantity of cement clinker. It is now proposed to expand its capacity by 50% by the installation of a third kiln. Capacity of the Whitehaven anhydrite mine is adequate to meet this additional demand. The bulk of the acid output is consumed by the company's associates Marchon Products Limited. Both companies belong to the Albright and Wilson Group.

Power-Gas Group

In Australia Power-Gas Ltd., of Stockton-on-Tees, have received an order from Standard-Vacuum Refining Company (Australia) Pty Limited to supply and erect at their Altona Refinery in Victoria an elemental sulphur recovery plant. To be designed in association with Comprimo N.V., under licence to N.V. De Bataafsche Petroleum Maatschappij, the plant is to come on stream in mid-1959. Using a modification of the conventional Claus kiln two-stage catalytic type, which will give 95%

recovery, the plant will recover 40 tons per day of elemental sulphur from H_2S provided by the refinery. Of particular interest is the third stage catalytic after-combustion of H_2S and SO_2 giving an effluent gas with an H_2S content of less than 5 ppm, thus minimising air pollution.

In India Power-Gas have secured a contract for a 50 ton per day sulphuric acid plant of Chemiebau Dr Zieren design for Travancore Rayons Limited, Perambavoor. This now makes an unusual concentration of Chemiebau sulphuric acid plants, as within twenty miles from Perambavoor, a 160 ton unit has nearly been completed, and within 120 miles a further 50 ton per day unit is being supplied.

INDIA

Acid and Superphosphate Plant Expansion

Dharamsi Morarji and Company, of Bombay, have been given permission to build a 50-ton per day contact sulphuric acid plant which it is hoped will be completed in early 1959. At present the company produce acid by three processes: chamber, contact and by the refining of spent acid obtained from the Burmah-Shell Refineries Limited. As a condition of the licence, the chamber plant, which has a capacity of 35 tons per day, and a 10 ton a day contact plant will be scrapped on the completion of the new plant. This will leave the company with facilities for producing 75-80 tons per day by the contact process and 25 tons per day by the spent acid process.

In addition the company have been licensed to expand the capacity of their single superphosphate plant from 80 tons per day to 120 tons per day, which expansion is expected to be completed by early 1959.

SOUTH AFRICA

New By-product Pyrite Plant

Harmony Gold Mining Company Limited have commenced expansion of the pyrites recovery plant at their gold mine in the Orange Free State. It is intended that the pyrite plant will come on stream mid-1959 and will have a monthly capacity for the treatment of 120,000 tons of gold ore slimes from which the company plan to produce 3,500 tons of pyrites concentrates per month. The sulphur content of the slimes is very low at 1.3% S, but the pyrite concentrates which are recovered by the flotation process contain 40% sulphur.

Work has commenced by Messrs. Simon-Carves Ltd. of Cheadle Heath, on the erection of a sulphuric acid plant with a rated capacity of 120 tons of 100% H_2SO_4 per day, and it is intended to complete this plant in the second half of 1959. The pyrites concentrates will be slurried and roasted in two Dorr-Oliver Fluo-Solids roasters which will produce a gas containing about 7% SO_2. This gas will pass through a waste heat boiler, a Peabody stripper, electrostatic mist precipitators and drying towers to clean and dry the gas before it is delivered to the contact acid plant. This will incorporate a four-pass catalytic convertor with heat exchangers and will be operated from a central control room. It is hoped to attain a conversion efficiency of about 97.5% and an overall recovery of sulphur from pyrites to acid of over 94%.

UNITED STATES

Fertilizer Project

The Bunker Hill Company is planning to build a 200,000 ton per year fertilizer plant costing $10 million, which will probably be sited in the State of Washington. This project, which is scheduled to start in mid-1960, is the logical sequel to its present activities which give rise to the manufacture of 100,000 tons of low cost sulphuric acid produced from roaster gases at the lead and zinc smelter at Kellogg,* Idaho. It is expected that the present level of production of acid will be increased considerably by the installation of additional plant for the utilization of all the SO_2 arising in the smelter gases. The installed Leonard-Monsanto contact acid plant is of standard design and rated to produce 300 short tons of 100% H_2SO_4 per day in the form of 93.2% H_2SO_4 (66° Bé) or 98-99% H_2SO_4.

The new fertilizer plant will manufacture a wide variety of phosphate fertilizers, initially using purchased Western phosphate rock. Geological investigations have been carried out and these may lead eventually to the company mining this raw material themselves if a suitable ore body can be discovered.

SPAIN

Pyrites Residues Cinder Extraction Project

Plans are nearing completion for the construction of a pyrites residues treatment plant near Bilbao. It is to have an annual treatment capacity of 200,000 tons residues which will

* Further technical details of this plant are described in Bulletin 15 (December 1956) pages 14-15.

be supplied by the sulphuric acid industries of North and Central Spain. Banco de Bilbao and San Telmo Iberica Minera S.A. are closely connected with the project which is receiving full technical support from Duisburger Kupferhütte.

SYRIA

Fertilizer/Sulphur Facilities

Among the first projects to be undertaken in Syria as a result of technical assistance from Communist countries is the production of superphosphate. This will probably be based on Jordanian phosphate rock and recovered sulphur from the new refinery being built at Homs by the Czechoslovakian State Enterprise, Technoexport, the oil for which is expected to come from the fields being developed in the Jazirah district of Northern Syria.

The capacity of the superphosphate plant will be 50,000 tons annually and that of the sulphur recovery unit 25,000 tons annually, although it is unlikely that the latter will be operated at first at more than 50% capacity. In view of the capacity of the sulphur unit it is improbable that deposits of sulphur in Northern Syria at Lake Ras-el-Ain will be developed unless the asphalt content of the deposits is worth recovering. Syria, which until the present has based its economy mainly on agriculture and entrepôt trade, is now developing a chemical industry in which petrochemicals and sulphur are expected to play an important part.

PERU

New Sulphuric Acid Plant

Industrias Basicas have completed a 50 tons per day sulphuric acid plant designed to burn Mexican sulphur and production is to commence in March 1959. The company have contracted the bulk of their acid to Fertiza, the new fertilizer plant built by Montecatini in Lima, for the production of ammonium nitrate.

The major established sulphuric acid producer is the Cerro de Pasco Copper Corporation at La Oroya where the 14,000 tons per year (100% H_2SO_4) plant is based on SO_2 from the smelter gas; apart from the sale of approximately 500 tons their entire acid production is used for electrolytic refining purposes at La Oroya. Rayon Peruana operate the only other sulphuric acid plant in Peru and in the manufacture of rayon and superphosphate consume approximately 75% of their annual production of 7,000 tons (100% H_2SO_4). The new plant will raise the installed acid capacity in Peru to approximately 38,000 tons 100% H_2SO_4. As the annual consumption is estimated to be 33,000 tons, it is likely that Peru will be able to export acid for the first time, probably to Bolivia and Chile.

URUGUAY

Sulphur Recovery

Administracion Nacional de Combustibles Alcohol y Portland, of Montevideo, are planning to build a sulphur recovery plant utilizing the exit gases from the Girbotol plant of their new refinery. Although the method has not as yet been selected the company have considered the recovery of sulphur through the conversion of hydrogen sulphide into either brimstone by the Claus process or into sulphuric acid by the wet contact process. Whichever method is adopted the bulk of the production which is due to commence in 1960, be it brimstone or sulphuric acid, will be consumed by the superphosphate plant.

The plant which is to come on stream early in 1960, is to be built by M. W. Kellogg Co. of Delaware. Administracion Nacional de Combustibles Alcohol y Portland of Montevideo already operate a "Chemico" contact sulphuric acid plant with a daily capacity of 20 tons (100% H_2SO_4.)

FORMOSA

Sulphuric Acid and Sulphur Recovery Facilities

Formosan domestic supplies of sulphur, which at present originate from mined sulphur and pyrites at an annual rate of 10,000 tons and 30,000 tons respectively, will shortly be augmented by the output of a sulphur recovery plant of the Chinese Petroleum Corporation. Situated on the company's oil refinery at Kaohsuing the plant, which has been designed and supplied by the German company Pintsch Bamag A.G., has an annual capacity of 3,000 tons high purity brimstone.

Most of the recovered sulphur output will be used in the manufacture of sulphuric acid to supply the company's new alkylation unit at the refinery. The acid plant, which will have a capacity of 15 tons (100% H_2SO_4) per day, is locally designed and constructed and should be on stream by the middle of April, 1959.

Statistical Appendix

West Germany

Thousand Metric Tons

PYRITES IMPORTS

	Spain	*Finland*	*Cyprus*	*Norway*	*Yugoslavia*	*Portugal*	*Canada*	*Cuba*	*Others*	*Total*
1948	213.3	—	39.5	181.4	—	—	—	—	27.7	461.9
1949	139.9	—	—	94.4	—	12.6	—	—	36.5	283.4
1950	355.0	—	99.0	91.0	—	45.1	—	—	49.0	639.1
1951	363.0	—	152.9	62.1	94.0	60.4	—	—	66.1	798.1
1952	404.6	—	235.9	59.5	105.7	59.7	0.2	—	146.8	1,012.4
1953	386.0	12.5	160.1	85.7	38.3	58.5	15.4	12.0	100.1	868.6
1954	404.0	33.4	240.9	127.8	80.7	50.5	37.1	37.0	43.7	1,055.1
1955	474.4	32.2	246.5	171.3	42.3	42.9	44.9	77.4	12.4	1,144.3
1956	567.4	35.8	312.8	155.9	28.2	66.9	67.2	73.4	20.5	1,327.1
1957	607.7	47.4	385.0	179.2	27.8	43.3	79.7	78.2	53.7	1,502.0

SULPHUR IMPORTS

	U.S.	*Italy*	*Mexico*	*Others*	*Total*
1948 ...	12.4	0.1	—	—	12.5
1949 ...	24.6	—	—	—	24.6
1950 ...	25.6	5.3	—	—	30.9
1951 ...	15.3	3.2	—	2.1	20.6
1952 ...	30.3	—	—	3.1	33.4
1953 ...	12.3	—	—	2.1	14.4
1954 ...	35.3	—	—	0.9	36.2
1955 ...	39.1	—	10.1	7.2	56.4
1956 ...	46.8	—	13.4	2.9	63.1
1957 ...	52.1	1.0	11.0	0.4	64.5

SULPHURIC ACID PRODUCTION

100% H_2SO_4

1938 ...	2,272	1948 ...	761
1939 ...	2,716	1949 ...	1,139
1940 ...	2,140	1950 ...	1,230
1941 ...	2,362	1951 ...	1,693
1942 ...	2,514	1952 ...	1,771
1943 ...	2,543	1953 ...	1,897
1944 ...	2,199	1954 ...	2,104
1945 ...	No data	1955 ...	2,163
1946 ...	342	1956 ...	2,530
1947 ...	517	1957 ...	2,718

United States

	3rd Qtr. 1958	*Jan.-Sept. 1958*		*3rd Qtr. 1958*	*Jan.-Sept. 1958*
Canada	98,882	210,751	United Kingdom	66,725	210,541
Argentina	4,293	23,071	West Germany	11,150	52,969
Brazil	24,979	73,474	Yugoslavia	—	2,000
Cuba	—	5,800	Algeria	4,700	14,560
N. Antilles	—	5,000	Iran	600	6,000
Peru	—	2,000	Israel	5,000	7,500
Uruguay	908	4,474	Lebanon	—	2,499
Venezuela	495	1,486	Morocco	—	3,500
Austria	—	18,017	South Africa	15,500	50,000
Belgium	15,100	64,930	India	31,899	85,625
Canary Isles	3,444	4,428	Pakistan	1,626	2,550
Finland	15,445	25,099	Australia	31,387	102,442
France	17,050	75,365	Indonesia	700	4,600
Netherlands	5,150	10,400	New Zealand	7,500	26,754
Poland	—	2,500	Others	1,335	3,013
Switzerland	10,450	40,905			
			Total (Long Tons)	374,318	1,142,253

Mexico

	Pan-American Sulphur Co.	*Gulf Sulphur Corp.*	*Total 3rd Qtr. 1958*	*Total Jan-Sept. 1958*
United States	108,374	46,263	154,637	411,864
United Kingdom	24,001	—	24,001	47,979
France	23,973	4,302	28,275	83,829
South Africa	13,621	—	13,621	37,929
Australia	4,622	—	4,622	46,311
Netherlands	3,052	17,471	20,533	27,791
Tunisia	10,169	—	10,169	28,015
Germany	3,352	—	3,352	9,997
Belgium	2,750	—	2,750	6,811
Canada	30,350	1,025	31,375	41,656
New Zealand	3,829	—	3,829	3,829
Israel	—	12,196	12,196	26,678
Formosa	—	—	—	4,033
Sweden	—	—	—	3,201
Total (Metric Tons)	228,094	81,257	309,351	778,913

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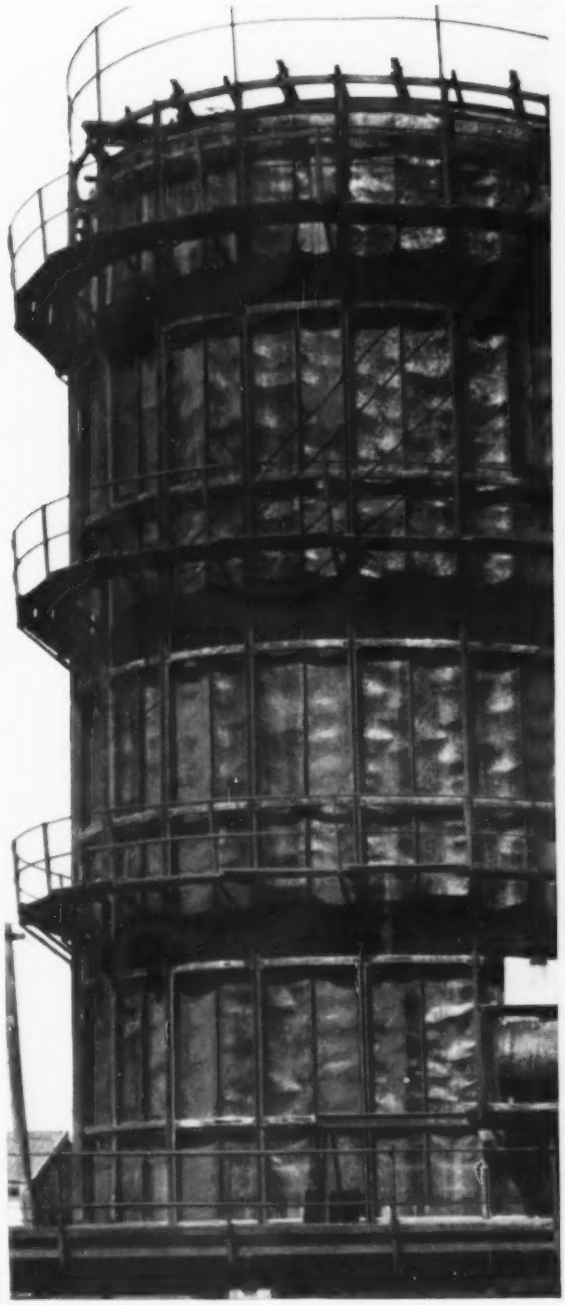

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